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Biological Oceanographic Conditions in the Northwest Atlantic During 2015

by

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Abstract

Biological and chemical variables collected in 2015 from coastal high frequency monitoring stations, semi-annual oceanographic transects, and ships of opportunity ranging from the Labrador-Newfoundland and Grand Banks Shelf (Subareas 2 and 3), extending west into the Gulf of St. Lawrence (Subarea 4) and further south along the Scotian Shelf and the Bay of Fundy (Subarea 4) and into the Gulf of Maine (Subarea 5) are presented and referenced to previous information from earlier periods when available. We review the interannual variations in inventories of nitrate, chlorophyll *a* and indices of the spring bloom inferred from satellite ocean colour imagery, as well as the abundance of major functional taxa of zooplankton collected as part of the 2015 Atlantic Zone Monitoring Program (AZMP). In general, nitrate inventories in the upper (0-50m) water-column were near to above normal compared to the 1999-2010 climatology throughout the northern Subareas but below normal from the southern Gulf of St. Lawrence down to the Scotian Shelf in 2015. The deeper (50-150m) nitrate inventories continue to remain well below normal on the Grand Bank but now approaching near normal on northern transects to well above normal in the Gulf of St. Lawrence and Scotian Shelf in 2015. The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys and fixed stations were variable throughout the Subareas with below normal conditions over the northern transects (2J to 3LNO), generally near normal in the Gulf of St. Lawrence and Scotian Shelf (SA4) in 2015. An exceptional localized record-high chlorophyll *a* inventory was observed along the northeast Gulf of St. Lawrence transects in 2015. Satellite ocean colour imagery detected intense surface concentrations centered over a broad area across the Labrador Sea and West Greenland Shelf during May 2015. This intense, large-scale spring bloom was in contrast to lower biomass and limited surface blooms observed over the NW Atlantic Shelves in 2015. The timing of the spring bloom varied with earlier onset in the northern regions coincident with the intense event over the Labrador Sea, in comparison to delayed timing observed from the northeast Newfoundland Shelf and southwards. An unusual exceptional record-early bloom occurred in the estuary within GSL in 2015. Despite the record-high magnitude and amplitude of the spring bloom in 2015 over the Labrador Sea and West Greenland, the duration of the production cycle was shortened throughout the standard sub-regions in 2015 with only a few exceptions. The abundance of different functional zooplankton groups consisting of combined copepods, non-copepods, and a small grazing copepod (*Pseudocalanus spp*.), were all above normal compared to the standard reference

period (1999-2010) in 2015. The abundance anomaly for the larger grazing copepod, *Calanus finmarchicus,* an important prey to a variety of different life stages of higher trophic levels, declined again in 2015 across the entire zone continuing a negative trend observed in earlier years. Development of a biological composite index time series incorporating lower trophic indices indicated the largest dynamic changes were associated with the Gulf of St. Lawrence while the smallest changes were observed on the Grand Bank – Flemish Cap. Further examination of the contributions of the various AZMP transects and fixed stations to the biological composite index revealed opposite trends between the LAB-NL and GSL-SS regions.

Introduction

We review biological and chemical oceanographic conditions on the Newfoundland (NL) and Labrador (LB) Shelves, Grand Bank (GB), Gulf of St. Lawrence (GSL), Scotian Shelf (SS), and in the Bay of Fundy (BoF) and Gulf of Maine (GoM) during 2015, and reference earlier periods when data are available. More frequent directed sampling from research vessels on oceanographic transects and ships of opportunity at coastal fixed stations by the Atlantic Zone Monitoring Program (AZMP[1]) and the completion of seasonal oceanographic surveys during 2015 provided good spatial and temporal series coverage of standard variables which affords a foundation for comparison with previous years. Additional details regarding physical, biological and chemical oceanographic conditions in the Northwest Atlantic in 2015 and earlier years can be found in Colbourne *et al.* (2015), Devine *et al.* (2015), and DFO (2015), Galbraith *et al.* (2015), Hebert *et al.* (2015), Johnson *et al*. (2016), Pepin *et al*. (2015), Plourde *et al.* (2014), Yashayaev *et al.* (2014).

Methods

Collections of standard AZMP variables are based on sampling protocols outlined by Mitchell *et al*. (2002). Observations for 2015 and earlier years presented in this document are based on seasonal surveys conducted during the spring through the autumn (typically March through December). The coastal stations are typically sampled at twice monthly to monthly intervals during ice-free conditions. The location of the standard oceanographic transects and coastal stations are shown in Figure 1.

Phytoplankton biomass was estimated from ocean colour data collected by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS; http://seawifs.gsfc.nasa.gov/SEAWIFS.html) and Moderate Resolution Imaging Spectroradiometer (MODIS) "Aqua" sensor (http://modis.gsfc.nasa.gov/). The SeaWiFS time series began in the September of 1997 and MODIS data stream began in July, 2002. Satellite data do not provide information on the vertical structure of chlorophyll *a* (chl*a*) in the water column but do provide highly resolved (~1.5 km) data on their geographical distribution in surface waters at the large scale. Two week composite images of chl*a* for the entire NW Atlantic (39-62.5° N Latitude 42-71° W Longitude) were routinely produced from SeaWiFS/MODIS data[2]. Basic statistics (mean, range, standard deviation, etc.) were extracted from the composites for selected statistical sub-regions as shown in Figure 1. We constructed an ocean colour time series from 1998 to 2015 using data from both satellite sensors and averaging during the overlap period from 2002 to 2010.

Scorecard indices were developed as a method of summarizing the many variables used to represent the state of lower trophic levels. To simplify the information, the time-series of the annual estimate of inventory or abundance for each summary variable was standardized to a mean of zero (for the period 1999 – 2010) and unit standard deviation ([observation – mean]/SD). The standard deviation provides a measure of the variability of an index. The result of this standardization yields a series of anomalies. The scorecards serve to illustrate departures from the long term mean across the range of variables by colour coding anomalies as either being above/later than (in red) or below/earlier than (in blue) the long term average, with darkening shades serving to represent the increasing magnitude of that departure. For the chemical-biological observations, the key variables selected were: (1) near surface (0-50 m) and deep (50-150 m) nitrate inventories, and (2) 0-100m integrated chl*a*, satellite indices of the magnitude and amplitude, peak timing

[1] http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html
[2] http://www.bio.gc.ca/science/newtech-technouvelles/sensing-teledetection/index-en.php

and duration of the spring bloom (Zhai *et al*. 2011), and zooplankton abundance for different functional zooplankton taxa (*Pseudocalanus spp*., *Calanus finmarchicus,* total copepods, and total non-copepod zooplankton) for the AZMP fixed stations and seasonal transects.

Annual Variability in Nutrient, Phytoplankton, and Zooplankton Conditions in the NAFO Subareas

Based on the available data, the upper water-column (0-50m integral) nitrate inventories varied throughout the northwest Atlantic with anomalies generally ranging within ± 1 SD units of the standard reference period (1999-2010) in 2014-2015 (Figure 2). The only exceptions occurred at the fixed sampling stations in the deep Avalon Channel and Prince-5 with below normal nitrate levels approaching – 2 SD units. The northern subareas generally showed above normal levels in shallow nitrate inventories in contrast to the Scotian Shelf which were mostly below the reference mean in 2015 (Figure 2). The annual anomalies in deep (50-150m integral) nitrate inventories were consistently negative across the southern LB and NL Shelves and GB in 2014-2015. An abrupt transition to relatively large positive anomalies in deep nitrate inventories of + 1-3 SD was observed in the GSL and SS Subareas (Figure 2). In general, the annual anomaly trends in nitrate inventories in the upper shallow layer have improved to near-normal levels in recent years (2014-2015) compared to record-low values observed in 2010-2011, particularly throughout the northeast NL Shelf and GB, and GSL subareas (Figure 3). The time series of deep nitrate inventories across the standard sections is characterized by high variability during the first half of the time series. The later time period shows a sustained reduction in deep nitrate inventories beginning in 2008-2009 and remains ongoing along the northern Subareas although the two-most northern sections have increased to near normal conditions in 2015 (Figure 3). Deep inventories continue to remain well below normal over the GB while levels have increased to record-high levels throughout the GSL and SS subareas (Figure 3). The chl*a* inventories inferred from the seasonal oceanographic surveys, which provides an index of phytoplankton biomass throughout the water-column, were consistently below normal along the northern transects and fixed station while conditions throughout the GSL and SS were generally near the reference period mean in 2014-2015 (Figure 4). The only exception was observed at H-2 fixed sampling site on the SS with – 2 SD units. Trends in chl*a* inventories remain mostly below normal with record-low values observed in 2015 over the GB and Flemish Cap (FC) transects and fixed station and ongoing over most of the northern sections since 2011 (Figure 5). Chl*a* inventories in the northeast GSL reached an exceptional record-high level in 2015 at + 7 SD units above normal (Figure 5). Trends in composite summed anomalies in nitrate and chla inventories showed coherent patterns between LB-NL and GB-FC transects along with similar trends between GSL and SS during the 17-year time series. The composite index for the upper water-column nitrate inventories showed large dynamic changes in GSL and SS subareas in comparison to lower magnitude changes observed for the LB-NL Shelves and GB (Figure 6). We also observed much larger amplitude changes and high interannual variability in deep nitrate inventories that appear to be strongly coupled between the GSL and SS transects but were largely decoupled from the northern areas (Figure 6). The clear downward trend in deep inventories over the LB-NL Shelves and GB ongoing since 2008 has increased with conditions approaching near-normal in 2015 (Figure 6). Similarly, the composite chla inventories also show large interannual changes across the GSL and SS compared to lower variability along the LB-NL Shelves and GB-FC transects and fixed stations with no distinct trend (Figure 6).

Annual anomalies were computed for each ocean colour metric during 2015 to evaluate spatial patterns across the different statistical sub-regions. The magnitude (integral of chl*a* biomass) and amplitude (peak intensity) of the spring bloom were exceptional and highest in the 18-year time series across W. Greenland and the Labrador Sea (Figure 7). In contrast, the magnitude and amplitude of the spring bloom along the northeast NL Shelf, GB, GSL, and SS sub-regions were characterized by mostly negative anomalies respectively (Figure 7). Peak timing of the spring bloom also showed mixed conditions with earlier timing in the northern regions coincident with the observed exceptional intense spring bloom while delayed onset of the production cycle was evident southwards from in the northeast NL Shelf (Figure 7). An unusual exceptional record-early bloom occurred in the estuary within GSL in 2015. Despite the record-high magnitude and amplitude of the spring bloom in 2015 over the Labrador Sea and West Greenland, the duration of the production cycle was shortened throughout the extent of the northwest Atlantic in 2015 with only a few exceptions (Figure 7).

Scorecards were constructed for each ocean colour metric extending back to the start of the time series in 1998. Overall, the magnitude of the spring bloom has generally been relatively weak over the entire zone during 2012-2015 with the exception of the record surface blooms over the Labrador Sea in 2015 (Figure 8). The 2008-2010 years were generally characterized by positive anomalies throughout the entire zone. The scorecards also reveal the extreme ± anomalies were associated with recent (2011-2015) years (Figure 8). The scorecard series for the amplitude (intensity) of the spring bloom typically varies within ± 2 SD from the start of the series until 2011 when more extreme values are observed (Figure 9). No consistent long-term trends in amplitude of blooms were detected within the time series. More coherent trends are apparent within the peak timing of the spring bloom during the 18-year time series compared to the magnitude and amplitude indices (Figure 10). In general, the onset of the spring bloom is relatively consistent over 2-5 year time spans with shifts between early and late timing across the zone. The early 2000's was characterized by a series of late spring blooms versus 2010-2012 that showed the reverse trend compared to the standard reference period (1998-2010). The late onset of the spring bloom is again apparent south of the northeast NL Shelf in 2015. No consistent trends in the duration of the spring bloom were observed during 1998-2010 but thereafter, a transition to limited duration is apparent throughout the zone (Figure 11). Most of the anomalies in spring bloom duration have been consistently negative reaching some of the highest levels in 2015.

We developed composite indices for each of the ocean colour metrics by summing all of the annual SeaWiFS/MODIS anomalies across the sub-regions located in the subarctic, LB-NL Shelves, GSL, GB, and SS-GoM to evaluate trends during the 18-year series. Overall, none of the metrics exhibit strong temporal trends in any of the composite anomalies in relation to the long-term mean (Figure 12). The main changes in the composite anomalies were often dominated by short-term (1-2 year) changes in the sign of the anomaly from positive to negative and vice versa across the different sub-regions during the series. Although high interannual variability is apparent for the different metrics, the composite time series shows somewhat higher levels during the later time period, particularly in the amplitude and duration of the spring bloom (Figure 12). The composite series for peak time of the spring bloom revealed periods of predominately early onset during the early 1990's, mid-2000's and 2010 along with delayed timing noted for the early-2000's, 2007-2008, and again in 2015 (Figure 12).

The pattern of annual anomalies for the different functional zooplankton groups showed consistent and coherent patterns and spatial gradients across the entire survey area in 2014-2015. The zooplankton abundance anomalies for a key small grazer and dominant copepod in the survey area, *Pseudocalanus spp*., were substantially higher again in 2015 similar to the pattern observed in the previous year with the largest positive anomalies (> 5 SD units) observed over the FC and Rimouski fixed sampling station in GSL (Figure 13). The only exception occurred across the SS with abundance near or slightly below normal during this time period. These small epipelagic, subarctic copepods represent an important preferred prey to many early life stages of fish. The abundance anomalies for the larger grazing copepod, *Calanus finmarchicus,* another dominant species and important prey item to higher trophic levels and energy transfer, were consistently below normal across the entire zone with the largest decline observed in the time series over the eastern SS at Cabot Strait in 2015 (Figure 13). In general, the decline in abundance of *C. finmarchicus* averaged between 1-2 SD below normal in 2014-2015 throughout the zone. The abundance of all combined copepod taxa remained mostly at higher levels but reached 1-4 SD units above normal on the GB, GSL, and portions of the western SS (Figure 13). The non-copepod (mostly larval stages of benthic invertebrates, gelatinous and carnivorous zooplankton) taxa continued to increase in abundance throughout the northeast NL Shelf and eastern GSL in 2014-2015 with remarkable positive anomalies in some cases reaching > 10 SD above normal at the Rimouski fixed station.

The scorecard indices for the small grazing copepod *Pseudocalanus* spp. has increased dramatically in recent years with above average abundance in 2010-2011 and again in 2013 along the northern transects and into the GSL although not previously observed during the time series (Figure 14). In contrast, the decline in another subarctic copepod, *Calanus finmarchicus* is ongoing in recent years throughout the northwest Atlantic although most prominently along the eastern SS since 2011 (Figure 14). The reduction in abundance of this dominant copepod is less pronounced in the GSL but has been consistently below normal since 2009. Despite the reduction in *C. finmarchicus*, the abundance of other dominant copepods increased in general throughout the zone during 2014-2015 (Figure 15). The overall pattern in abundance of combined copepods is higher

along the northern transects from 2006 onwards while lower levels are apparent in the GSL and SS from 2009-2013 (Figure 15). The non-copepod group, which consists of gelatinous forms, meroplankton, and carnivorous zooplankton, also continue to show substantial increased abundance and some of the highest levels observed in the time series throughout the zone and record-high levels (> 10 SD units) in the GSL with above average abundance also observed along the SS transects in 2014-2015 (Figure 15).

The composite indices summing each of the functional zooplankton indices across the LB-NL Shelves, GB, GSL and SS transects and fixed stations revealed some contrasting patterns during the time series. The summed composite abundance anomalies for the small copepod *Pseudocalanus* spp. showed relatively consistent near-normal levels on the LB-NL Shelves and GB throughout the 2000's but much larger dynamic changes in the GSL and SS areas from 2010 onwards (Figure 16). Composite abundance anomalies for the large grazing copepod *Calanus finmarchicus* show a rapid and continuing negative trend along the GSL and SS transects while the downward trend in northern areas is less pronounced (Figure 16). The trend in composite anomalies for total copepods and non-copepods is remarkably consistent and stable throughout the time series with significant elevated abundances in these two functional groups observed in recent years along the GSL transects and fixed stations (Figure 16).

We developed intensity composite plots of annual standardized anomalies for the different trophic level indices which included the nutrient inventories and phytoplankton biomass, the functional zooplankton groups, and an overall composite trophic index from designated AZMP sub-regions and NAFO Subareas. Examination of the intensity plots of the combined nutrient and phytoplankton inventories shows the largest dynamic changes associated within the GSL time series (Figure 17). Although the composite nutrient and phytoplankton inventories were negative throughout the entire zone during 2010-2011, the combined indices have increased significantly in the GSL (SA4) in recent years which is not the case on the LB-NL Shelves, GB-FC and SS transects with relatively small changes during the time series. The intensity plots of the combined annual anomalies of zooplankton functional groups also indicated the largest dynamic changes were observed within the GSL (SA4) time series but have also been noted to a lesser extent along the LB-NL and GB-FC areas (Figure 18). The largest changes in the composite zooplankton time series have been associated with recent years (2014-2015) along the LB-NL, GB-FC, and GSL and are mostly positive with the exception of more limited changes observed along the SS transects. The smallest changes in the composite zooplankton time series were associated with SA2, SA2-3 (2J-3K Divs.) and SA3 (3LNO Divs.) showing low variability throughout the temporal records (Figure 18). Summing all individual composite indices into an overall trophic index indicates the largest dynamic change was associated with the GSL (SA4) with the highest positive levels observed in 2014-2015 (Figure 19). The least extensive changes in the overall composite intensity plot were observed from the southern LB Shelf (SA2) down to the southern GB (3LNO Divs.) with anomalies ranging from ± 0-5 SD units (Figure 19). Further examination of the individual AZMP transect and fixed station components provided additional detailed spatial information of the different transects and fixed stations to the biological composite index. We observed a sustained decline in the composite index from 2009 until 2014 with relatively large contributions from the LB and northeast NL Shelf transects (Figure 20). During this same time period, the reverse trend was apparent in the composite index based on transects and fixed stations within the GSL (Figure 21). The biological composite series on the SS closely mirrors the pattern within the GSL with a sustained positive trend from 2010 onwards (Figure 22).

Patterns of variation in the lower trophic levels, consisting of standing stocks of nitrate, phytoplankton and zooplankton, appear dominated by short term fluctuations that may be related to different water masses, changes in circulation and physical properties, the patchy distribution of organisms and relatively short life histories, along with the limited sampling coverage by the monitoring program. The current state of the lower trophic levels appears to demonstrate some spatial structuring, with transitions in biological oceanographic conditions often associated between the northern areas on the LB-NL Shelves and locations further south in the GSL and SS. This was particularly evident in deep nitrate and chlorophyll *a* inventories, ocean colour indices and zooplankton standing stocks with strong spatial changes and gradients along the Atlantic Zone.

Biological Oceanographic Highlights in 2015

- Deep (>50m) nitrate inventories continue to remain well below normal in 2014-2015 over the southern Labrador and Newfoundland Shelf and Grand Bank (ongoing since 2008) while levels have increased above the long-term mean throughout the Gulf of St. Lawrence and generally near or above normal along the Scotian Shelf.

- The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys, a proxy of phytoplankton biomass, were generally lower over the northern transects and near the long-term reference mean throughout the Gulf of St. Lawrence and Scotian Shelf.

- In general, the magnitude and amplitude of the spring bloom inferred from remote sensing data were significantly higher in northern sub-regions but lower over the Gulf of St. Lawrence and NE Newfoundland Shelf and Grand Bank in 2015.

- The onset of the spring bloom was delayed over many of the sub-regions with the exception of northern areas and estuary in Gulf of St. Lawrence.

- Despite the extensive bloom over the Labrador Sea, the duration of the spring bloom was typically below normal compared to the reference climatology in 2015.

- A large increase in abundance of *Pseudocalanus* spp. was observed in 2015 over much of the northern transects and fixed stations and throughout the Gulf of St. Lawrence.

- A steady decline in the abundance in *C. finmarchicus* is continuing in 2015 and previous years throughout the northwest Atlantic.

- Total copepods and non-copepods functional groups show similar trends with a small increase over the time series except for Gulf of St. Lawrence with exceptional levels in 2014-2015.

- The biological composite index, summarizing combined lower trophic indices indicated the largest dynamic changes were associated with the Gulf of St. Lawrence while the smallest changes were observed on the Grand Bank – Flemish Cap.

- The composite index shows opposing trends between the Newfoundland and Labrador Shelves and Gulf of St. Lawrence – Scotian Shelf during the later time series.

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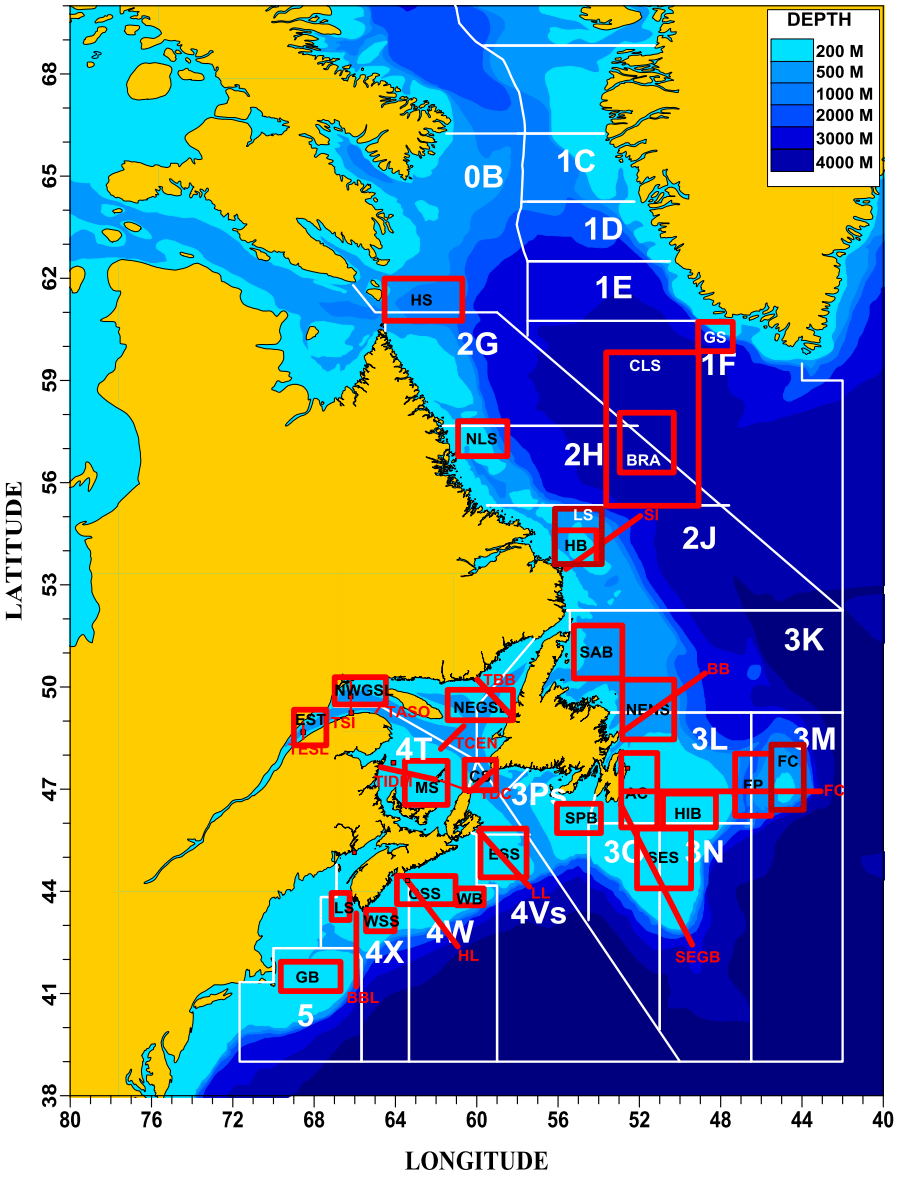

Fig. 1. Location of the NAFO Regulatory Areas (white boxes) and standard Atlantic Zone Monitoring Program (AZMP) fixed coastal stations (closed red squares) and oceanographic transects (red lines). The statistical sub-regions (Petrie Boxes) shown by the open red boxes (HS=Hudson Strait, GS=Greenland Shelf, CLS=central Labrador Sea, NLS=northern Labrador Shelf, LS=Labrador Shelf, HB=Hamilton Bank (Seal Island), SAB=St. Anthony Basin, NENS=northeast Newfoundland Shelf, AC=Avalon Channel, FP=Flemish Pass, FC=Flemish Cap, HIB=Hibernia, SPB=St. Pierre Bank, SES=southeast Shoal, CS=Cabot Strait, MS=Magdalen Shallows, NEGSL=northeast Gulf of St. Lawrence, NWGSL=northwest Gulf of St. Lawrence, EST = Estuary, ESS=eastern Scotian Shelf, WB=Western Bank, CSS=central Scotian Shelf, WSS=western Scotian Shelf, LS=Lurcher Shoal, GB=Georges Bank. The standard AZMP transects are SI=Seal Island, BB=Bonavista Bay, FC=Flemish Cap, SEGB=southeast Grand Bank, TESL=Lower St. Lawrence Estuary, TSI=northwest Gulf of St. Lawrence, TASO=southwest Anticosti, TBB=Bonne Bay (northeast Gulf of St. Lawrence), TCEN=Centre Gulf of St. Lawrence, TIDM=Magdalen Shallows, TDC=Cabot Strait, LL=Louisbourg Line, HL=Halifax Line, BBL=Browns Bank Line, and fixed stations (Station 27, Rimouski, Anticosti Gyre, Gaspé Current, Shediac Valley, Halifax-2, and Prince-5).

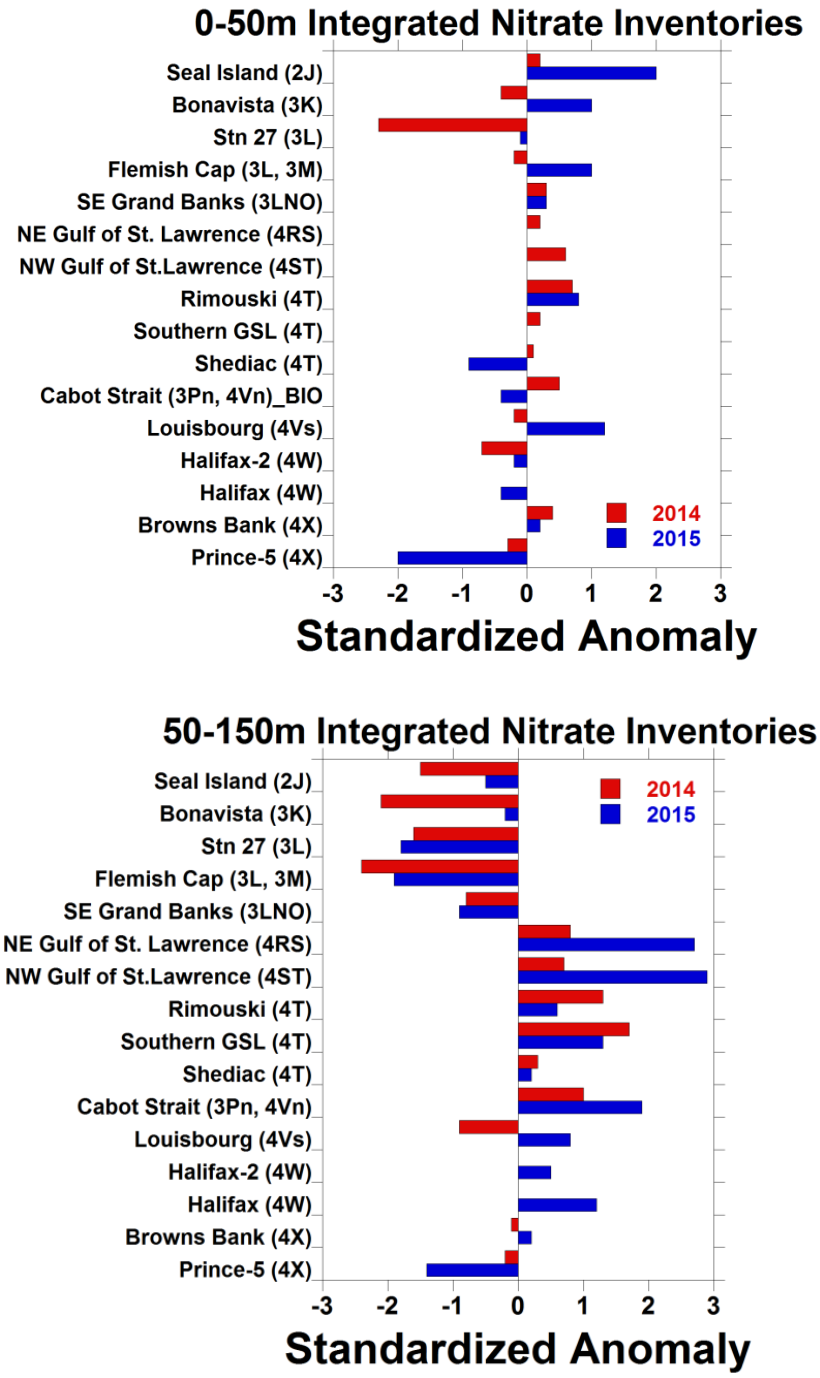

Fig. 2. Summary of nitrate (combined nitrate and nitrite which represents the principal limiting nutrient in the system) from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2014 (top panel) and 2015 (bottom panel). The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1999-2010) divided by the standard deviation. The nutrient anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

Nitrate (0-50m)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seal Island (2J)	-1.0	-0.6	-0.2	0.2		1.4	0.0	-1.9	0.4	-0.5	0.8	1.4	1.0	0.7	-1.2	0.2	2.0
Bonavista (3K)	0.0	-0.2	-0.4	1.6	1.6	0.3	-0.6	-1.5	1.2	-0.4	-0.3	-1.2	0.1	-0.5	-0.6	-0.4	1.0
Stn 27 (3L)		-0.1	1.8	-0.5	0.7	0.6	0.2	-0.8	0.6	0.1	-0.6	-2.1	-0.5	-1.3	-0.6	-2.3	-0.1
Flemish Cap (3L, 3M)	-0.1	-0.8	0.3	1.1	2.0	0.6	-0.5	-0.5	0.7	-0.7	-0.7	-1.6	1.5	-0.7	-0.6	-0.2	1.0
SE Grand Banks (3LNO)	0.0	-0.5	-0.1	0.2	2.5	0.7	0.2	-0.9	0.3	-0.5	-0.4	-1.6	-0.8	0.2	-1.3	0.3	0.3
NE Gulf of St. Lawrence (4RS)	1.3	1.4	-0.2	0.5	1.0	-1.6	-0.8	-0.9	0.9	-0.3	-0.5	-0.9	-2.2	-1.6	-0.7	0.2	
NW Gulf of St.Lawrence (4ST)	1.0	-0.3	1.4	2.0	0.3	-1.1	-0.6	0.2	-0.8	-0.5	-0.9	-0.7	-1.2	0.7	0.9	0.6	
Rimouski (4T)	-0.2	1.1	0.0	1.8	-0.6	0.9	-0.2	0.0	-0.5	0.7	-1.1	-1.8	-0.7	-0.5	0.0	0.7	0.8
Southern GSL (4T)	-1.4	0.8	0.1	0.5	-0.4	0.5	0.1	2.2	-0.6	0.3	-0.5	-1.6	-2.1	-1.2	0.2	0.2	
Shediac (4T)	0.3	1.2	-0.8	0.4	-0.4	0.9	-0.5	1.0	-1.6	0.4	0.9	-1.7	-1.4	-0.2	-0.1	0.1	-0.9
Cabot Strait (3Pn, 4Vn)_BIO	1.9	-0.1	-0.5	0.3	0.2	-1.2	0.1	-0.7	0.9	1.1	-0.4	-1.6	1.5	0.6	2.4	0.5	-0.4
Louisbourg (4Vs)	1.3	1.1	-1.1	-2.1	0.4	-0.8	-0.5	0.2	0.3	1.1	-0.2	0.3	-0.2	-0.3	0.7	-0.2	1.2
Halifax-2 (4W)	-1.9	1.1	0.9	-1.1	1.0	-0.1	-0.3	0.1	0.2	1.4	-0.2	-0.9	-0.6	-2.7	0.8	-0.7	-0.2
Halifax (4W)	2.0	0.6	0.3	-0.7	-0.8	-1.2	-0.5	-0.2	-0.9	1.7	-0.4	0.2	0.7	1.4	1.8	0.0	-0.4
Browns Bank (4X)	0.0	1.7	0.0	0.2	-1.4	-0.4	0.1	0.0	-1.8	1.6	0.4	-0.4	0.9	-0.2	0.7	0.4	0.2
Prince-5 (4X)	-1.5	-0.5	-0.9	0.9	0.9	0.0	-0.3	1.4	-0.3	0.4	1.4	-1.4	0.3	0.4	-0.5	-0.3	-2.0

Nitrate (50-150m)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seal Island (2J)	0.0	0.5	0.4	0.4		0.8	0.5	0.4	1.3	-2.0	-0.9	-1.4	-0.7	-1.6	-2.8	-1.5	-0.5
Bonavista (3K)	0.8	0.9	-1.4	-0.1	0.8	0.8	0.2	0.7	0.8	-0.5	-0.6	-2.1	-1.4	-1.3	-2.6	-2.1	-0.2
Stn 27 (3L)		1.4	0.2	0.2	-0.7	-0.6	0.0	-0.1	0.9	1.4	-0.8	-1.9	-1.0	-1.0	-2.0	-1.6	-1.8
Flemish Cap (3L, 3M)	0.7	0.6	-0.3	-1.0	0.8	0.0	0.4	1.4	0.9	-0.3	-1.2	-2.0	-0.1	-2.3	-2.1	-2.4	-1.9
SE Grand Banks (3LNO)	1.5	-0.4	-0.2	0.9	0.3	1.0	0.2	0.5	0.0	-0.2	-2.3	-1.1	-0.4	-0.4	-1.7	-0.8	-0.9
NE Gulf of St. Lawrence (4RS)	1.0	1.4	-1.7	-0.1	0.0	-1.5	-0.9	1.4	0.3	0.0	0.1	0.0	-0.4	0.3	0.4	0.8	2.7
NW Gulf of St.Lawrence (4ST)	0.6	-1.3	0.3	1.1	0.5	-1.5	-0.9	1.6	0.2	0.4	0.2	-1.3	-0.9	1.7	0.3	0.7	2.9
Rimouski (4T)		-0.5	0.9	1.4	-1.3	-0.4	-0.1	0.7	1.3	-1.0	0.3	-1.3	-1.2	0.4	-0.7	1.3	0.6
Southern GSL (4T)	-0.9	0.7	-1.4	0.3	0.2	-0.3	-0.9	2.0	-0.5	1.0	0.6	-1.0	-0.9	1.0	1.4	1.7	1.3
Shediac (4T)	0.3	1.3	0.2	1.0	0.4	0.5	-0.7	0.7	-1.7	0.5	-0.5	-2.0	-1.6	-0.3	-0.3	0.3	0.2
Cabot Strait (3Pn, 4Vn)	-0.1	2.0	-1.3	0.0	0.0	-0.9	-0.6	1.5	-0.9	0.0	0.9	-0.6	-0.6	1.6	0.7	1.0	1.9
Louisbourg (4Vs)	0.6	1.3	-1.3	-1.6	0.5	-0.5	-0.5	1.7	-0.9	0.1	0.2	0.4	-0.9	0.1	-0.9	-0.9	0.8
Halifax-2 (4W)	-0.1	1.4	-0.7	0.7	1.3	-0.6	-2.0	0.7	-0.8	0.5	0.3	-0.6	-0.7	1.7	-0.2	0.0	0.5
Halifax (4W)	0.9	1.3	0.1	-0.4	-1.4	-0.4	-1.6	1.0	-0.8	0.9	1.0	-0.6	-0.8	0.0	0.1	0.0	1.2
Browns Bank (4X)	-0.2	0.5	0.2	-0.7	-1.9	1.8	-0.4	0.5	-1.4	0.1	0.6	1.0	0.5	2.0	0.6	-0.1	0.2
Prince-5 (4X)	-1.2	-0.5	-1.0	1.1	1.1	-0.4	-0.4	1.1	-0.4	0.4	1.6	-1.3	-0.6	0.7	-0.6	-0.2	-1.4

Fig. 3. Time series of shallow (0-50m) and deep (50m-bottom) nitrate (combined nitrite and nitrate) inventory anomalies from different oceanographic transects and fixed stations (in bold) from the Atlantic Zone Monitoring Program during 1999-2015. The anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. Empty white cells indicate missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences in the annual average value from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted roughly by latitude from north (top) to south (bottom) regions.

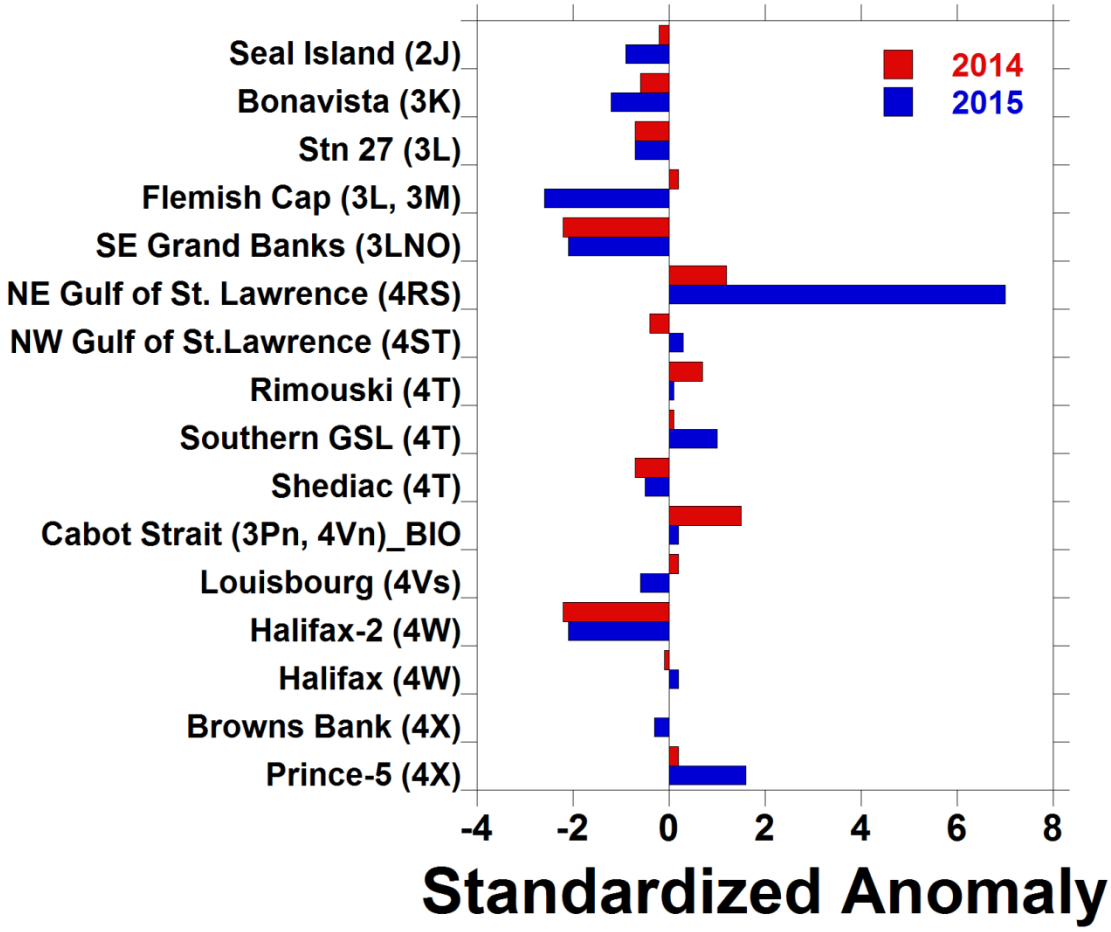

Fig. 4. Summary of chlorophyll *a* inventories (0-100m integral) from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2014-2015. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1999-2010) divided by the standard deviation. The chlorophyll *a* anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

Chlorophyll *a* (0-100m) Biomass	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Seal Island (2J)	2.7	0.1	0.8	0.1	-0.8	-0.4	-0.1	0.1	-0.9	-0.9	-0.1	-0.7	-1.0	-0.9	-0.9	-0.2	-0.9
Bonavista (3K)	-1.4	1.2	0.1	-1.2	-1.5	0.6	0.6	0.6	0.4	-0.9	1.4	0.1	-1.3	-1.7	-0.7	-0.6	-1.2
Stn 27 (3L)	3.1	-0.1	0.0	-0.1	-0.4	-0.2	-0.6	-0.2	-0.3	-0.7	-0.2	-0.3	-0.7	-0.4	-1.0	-0.7	-0.7
Flemish Cap (3L, 3M)	2.1	-0.2	-0.1	-0.9	-1.8	0.0	0.2	-0.7	0.9	-0.5	1.0	0.0	-2.0	-1.5	-0.1	0.2	-2.6
SE Grand Banks (3LNO)	1.8	-1.5	0.2	-0.3	-1.1	-0.4	0.4	-0.7	1.1	-0.8	1.3	0.1	-1.7	-0.7	1.0	-2.2	-2.1
NE Gulf of St. Lawrence (4RS)	0.1	-0.6	-1.3	2.5	0.1	-0.1	-1.3	-0.8	0.1	0.5	0.5	0.1	-0.6	-0.1	1.0	1.2	7.0
NW Gulf of St.Lawrence (4ST)	0.3	-1.9	-0.1	2.4	0.7	0.0	-0.5	-0.4	-0.4	0.6	-0.5	-0.3	-1.2	0.4	-1.8	-0.4	0.3
Rimouski (4T)	2.9	-0.4	0.1	-0.2	0.4	-0.9	-0.7	-0.5	0.4	-0.9	-0.1	-0.2	-0.2	0.1	-0.3	0.7	0.1
Southern GSL (4T)	0.4	-1.4	0.4	2.3	0.4	-0.9	-0.9	-0.5	0.7	-0.7	-0.4	0.6	-0.7	0.1	0.6	0.1	1.0
Shediac (4T)	-0.5	-1.0	-0.1	1.7	0.6	-0.8	-1.5	0.5	1.0	1.1	0.1	-1.1	-1.3	-0.4	0.1	-0.7	-0.5
Cabot Strait (3Pn, 4Vn)_BIO	1.4	2.0	-0.9	0.9	-0.3	0.2	-0.9	-0.3	-0.1	-0.9	0.1	-1.2	-0.2	-0.2	-1.0	1.5	0.2
Louisbourg (4Vs)	-0.4	0.2	-0.6	0.1	2.5	0.2	0.2	-0.6	0.9	-0.4	-0.5	-1.5	0.9	-0.1	0.3	0.2	-0.6
Halifax-2 (4W)	1.8	-1.5	0.2	-0.3	-1.1	-0.4	0.4	-0.7	1.1	-0.8	1.3	0.1	-1.7	-0.7	1.0	-2.2	-2.1
Halifax (4W)	-0.8	-0.1	-0.4	0.0	0.5	-0.5	0.7	-0.9	2.6	0.0	0.1	-1.3	0.0	-0.4	-0.1	-0.1	0.2
Browns Bank (4X)	-0.7	-0.4	-0.6	0.0	0.8	-0.2	-0.4	-1.0	2.5	-0.7	1.1	-0.3	-0.6	0.4	-0.6	0.0	-0.3
Prince-5 (4X)	0.6	2.4	-0.9	-0.3	0.2	0.3	-1.1	-0.6	0.3	0.2	-1.5	0.4	-1.1	0.5	3.5	0.2	1.6

Fig. 5. Time series of chlorophyll *a* (0-100m) inventory anomalies from different oceanographic transects and fixed stations (in bold) from the Atlantic Zone Monitoring Program during 1999-2015. The anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. Empty white cells indicate missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences in the annual average value from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted roughly by latitude from north (top) to south (bottom) regions.

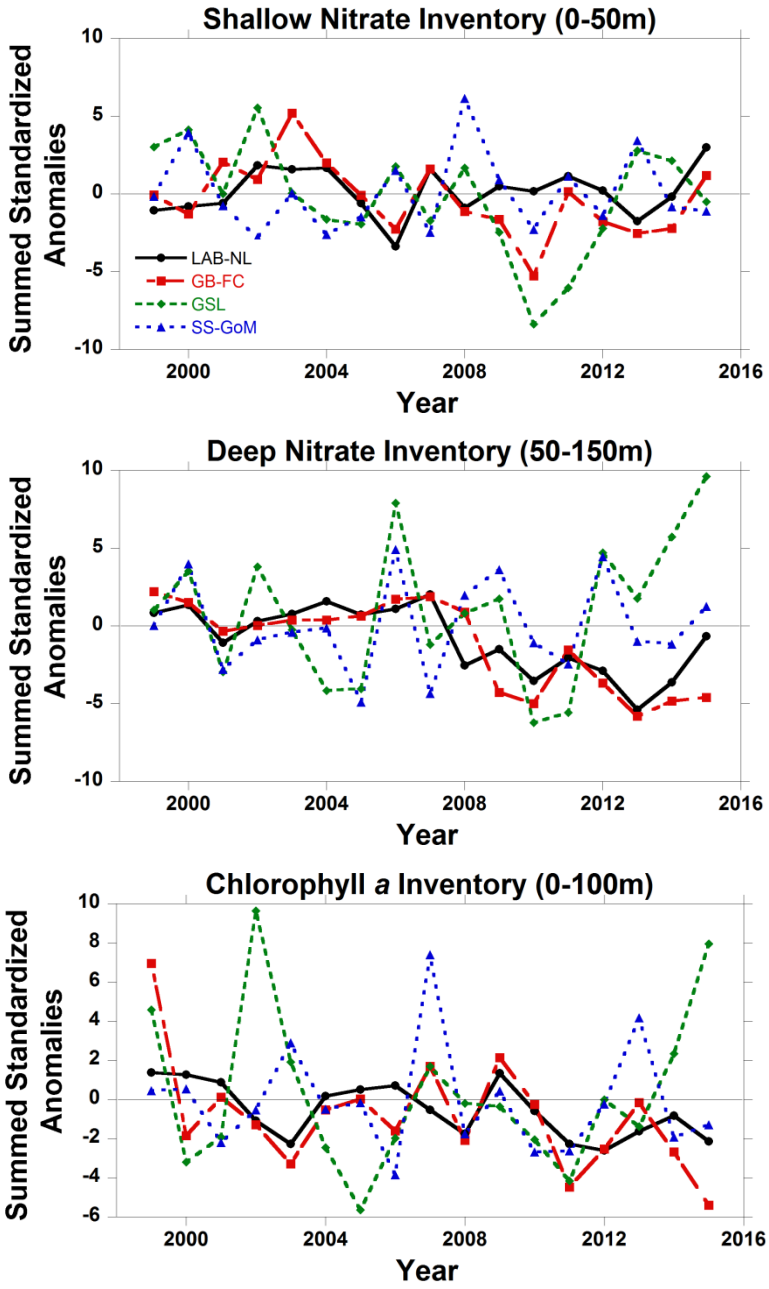

Fig. 6. Composite sums of annual anomalies across Labrador and the northeast Newfoundland (LAB-NL) Shelf, Grand Bank and Flemish Cap (GB-FC), Gulf of St. Lawrence (GSL), Scotian Shelf and Bay of Gulf of Maine (SS-GoM) transects and fixed stations for shallow (0-50m) and deep (50m-bottom) nitrate and chlorophyll *a* inventories during 1999-2015.

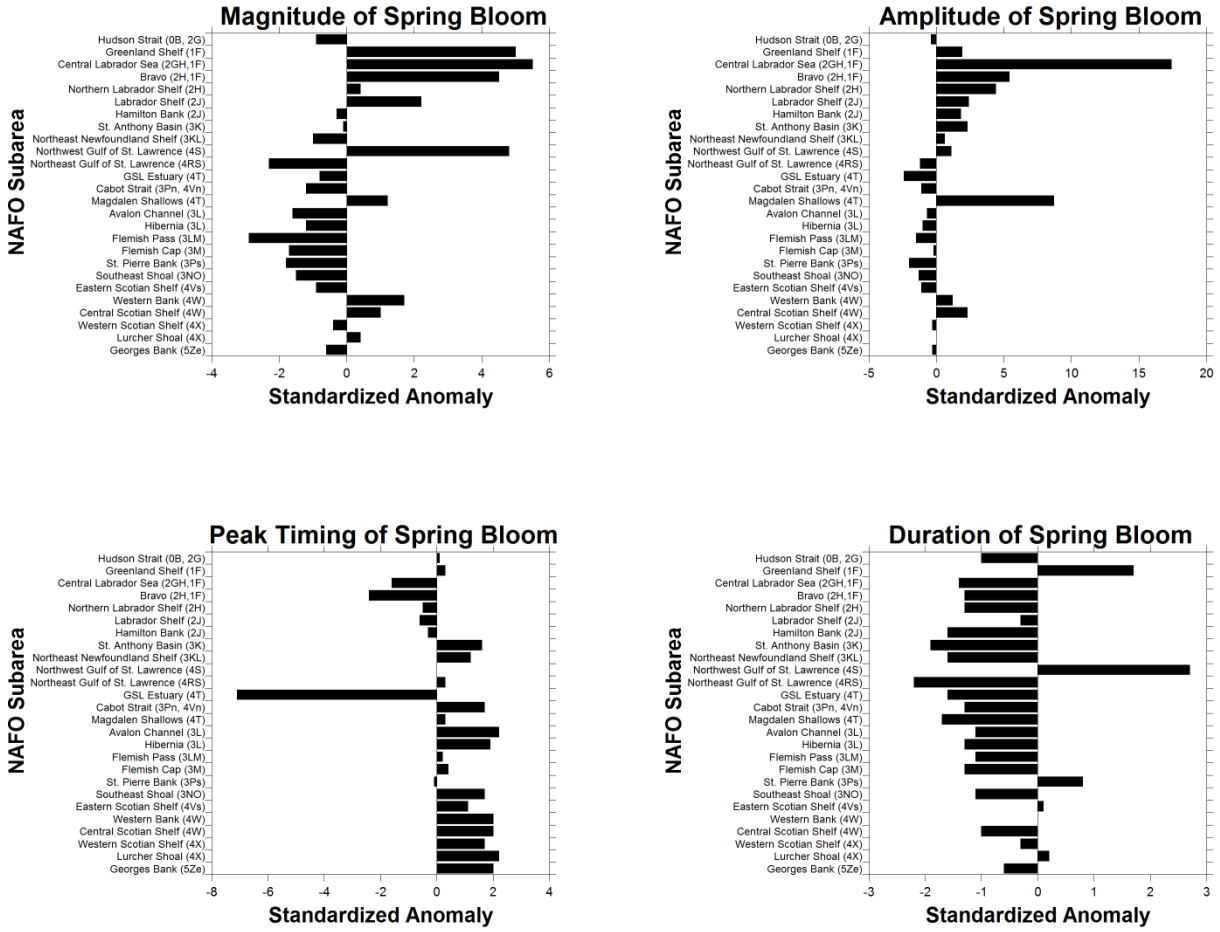

Fig. 7. Summary of annual ocean colour anomalies from SeaWiFS and MODIS "Aqua" sensor across the different statistical sub-regions during 2015. The top panels show the magnitude and amplitude of the spring bloom while the bottom panels show peak timing and bloom duration indices. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1998-2010) divided by the standard deviation. The NAFO Subareas are sorted from northern (top) to southern (bottom) regions. Negative anomalies for the timing indices indicate earlier/shorter blooms while positive anomalies indicate the opposite.

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1998-2010 Mean ± SD	% Difference in 2014	% Difference in 2015
Hudson Strait (0B, 2G)	0.2	-0.7	-0.3	-0.8	-0.5	3.0	-0.4	0.1	0.8	-0.5	-0.4	-0.6	0.1	-0.8	-0.6	-0.5	-1.2	-0.9	160	-67	-48
Greenland Shelf (1F)	0.0	0.7	-0.5	1.7	0.9	0.3	-0.9	-1.2	1.0	0.8	-1.5	-1.0	-0.4	0.9	-0.4	-0.7	-1.3	5.0	110	-70	259
Central Labrador Sea (2GH,1F)	0.0	-0.5	-1.1	-1.2	-0.8	1.0	0.6	1.5	-0.9	1.3	0.5	-1.3	0.9	4.3	-0.6	-1.5	-0.7	5.5	73	-35	271
Bravo (2H,1F)	0.2	-0.9	-0.8	0.1	-0.7	0.4	0.5	0.4	0.4	-1.1	0.5	-1.3	2.4	-1.3	-0.4	-1.7	-0.8	4.5	82	-44	250
Northern Labrador Shelf (2H)	0.0	0.0	-0.7	0.6	-1.0	0.7	-0.7	-0.1	-0.1	-0.5	2.8	0.0	-1.1	-0.8	-0.7	-1.6	-1.0	0.4	41	-54	21
Labrador Shelf (2J)	-0.2	0.8	-0.6	-0.1	-0.7	-0.1	-1.5	-0.2	0.8	-1.4	2.0	0.1	1.1	-0.4	-0.8	-1.1	-0.5	2.2	50	-22	101
Hamilton Bank (2J)	-0.4	0.7	-1.1	1.5	-1.0	-0.5	-1.0	-0.2	0.9	-1.5	0.5	1.0	1.1	-0.9	-0.1	-1.6	-1.3	-0.3	68	-48	-10
St. Anthony Basin (3K)	-0.3	0.3	-0.9	0.0	0.7	-0.3	-0.5	-0.8	-0.3	-0.6	3.0	0.3	-0.5	0.7	-0.5	-0.7	-1.0	-0.1	91	-82	-7
Northeast Newfoundland Shelf (3KL)	0.1	0.2	0.6	-1.4	0.1	-0.5	-0.7	-0.8	1.6	-0.2	-0.7	2.3	-0.4	3.1	-0.9	-1.3	-1.0	-1.0	79	-49	-48
Northwest Gulf of St. Lawrence (4S)	1.0	-0.2	-0.2	0.9	-1.4	0.6	1.5	0.0	0.6	-1.0	0.8	-1.7	-1.0	-1.8	3.9	-0.2	0.5	4.8	176	13	137
Northeast Gulf of St. Lawrence (4RS)	1.7	-1.0	-1.2	-0.1	-0.7	-0.3	0.4	-0.6	-0.2	0.3	-0.5	-0.1	2.3	-0.2	-0.3	0.9	-1.8	-2.3	48	-65	-86
GSL Estuary (4T)	-0.6	-0.1	-0.7	0.1	0.2	0.0	-0.1	-0.2	-0.1	-0.4	3.2	-0.7	-0.5	-0.7	-0.4	1.1	-0.6	-0.8	1386	-74	-68
Cabot Strait (3Pn, 4Vn)	1.1	0.3	0.0	-0.8	0.2	0.3	-0.6	-1.2	2.1	1.0	-1.3	-0.1	-1.0	0.1	1.6	-0.3	0.1	-1.2	83	5	-72
Magdalen Shallows (4T)	-0.3	-1.4	0.6	-0.2	0.9	0.5	-0.7		-1.5	1.4	-1.0	0.8	1.0	0.6	3.0	-0.3	0.4	1.2	81	12	43
Avalon Channel (3L)	-1.5	-0.7	-0.7	-0.2	0.4	-0.3	-0.4	-0.8	0.2	0.4	-0.2	1.3	2.4	0.8	-0.9	-0.6	-0.9	-1.6	62	-37	-63
Hibernia (3L)	-0.6	1.7	1.7	-0.9	-0.2	-1.3	0.6	-1.1	-0.3	-0.3	1.0	0.3	-0.5	-0.1	-1.0	-0.6	-0.5	-1.2	123	-29	-76
Flemish Pass (3LM)	-1.5	-0.4	0.0	-1.2	1.8	-0.3	0.3	0.6	-0.3	-0.2	-1.1	1.5	0.9	-1.5	-0.8	-0.1	-1.8	-2.9	84	-53	-83
Flemish Cap (3M)						0.6	0.1	0.8	1.2	-1.6	-0.7	-1.0	0.6	-1.0	-0.2	-0.1	-0.7	-1.7	106	-33	-76
St. Pierre Bank (3Ps)	-0.8	-0.4	-1.1	1.7	-0.2	-0.7	0.0	-0.5	0.1	-0.2	-1.0	1.8	1.3	0.5	1.4	-1.2	-0.5	-1.8	51	-20	-75
Southeast Shoal (3NO)	-0.4	0.5	-1.6	0.0	1.3	-0.5	-0.8	-1.0	0.2	-0.8	1.9	1.0	0.2	0.5	-0.9	0.8	2.0	-1.5	88	101	-75
Eastern Scotian Shelf (4Vs)	0.9	-1.0	0.1	-1.2	0.4	-0.3	-0.5	-1.1	0.5	2.2	1.0	-0.7	-0.3	1.0	2.0	0.8	-1.3	-0.9	81	-59	-41
Western Bank (4W)	-0.4	-0.4	-0.7	0.0	-0.1	1.2	0.4	-1.1	-0.5	1.7	-1.4	1.8	-0.4	6.1	-0.6	-1.0	0.6	1.7	35	33	96
Central Scotian Shelf (4W)	-1.3	-0.1	0.7	-0.1	0.2	1.5	-0.6	-1.6	0.2	1.7	-0.2	0.7	-1.1	-0.6	0.3	-0.8	-0.5	1.0	50	-19	39
Western Scotian Shelf (4X)	-0.9	-0.6	-1.3	-0.6	0.1	1.7	-1.4	1.3	1.3	0.2	0.2	0.4	-0.5	-0.7		-0.1	-1.0	-0.4	57	-58	-21
Lurcher Shoal (4X)	-0.9	-1.0	-1.1	0.6	0.5	0.1	-0.7	-0.9	0.1	-0.3	-0.6	0.6	2.5			-0.8		0.4	38	-100	37
Georges Bank (5Ze)	-1.1	-0.5	-0.5	-0.3	0.8	0.7	0.4	-0.6	-0.5	-0.7	-0.6	2.7	0.1	1.2	-0.7	-0.9	-0.7	-0.6	112	-54	-49

Fig. 8. Annual anomalies of the magnitude (integral of chlorophyll *a* concentration during the bloom in mg m^{-2} d^{-1}) of the spring bloom derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2015. Blue cells indicate lower than normal levels and red cells indicate higher than normal levels. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between a given year and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells). The unstandardized mean during 1998-2010 is provided along with % differences between reference period and 2014 and 2015 respectively.

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1998-2010 Mean ± SD	% Difference in 2014	% Difference in 2015
Hudson Strait (0B, 2G)	-0.7	0.4	-0.4	0.8	-0.9	1.0	-1.3	-0.1	-0.2	-1.3	1.4	1.7	-0.7	-2.0	-1.7	-1.0	-0.3	-0.4	1.5	-7	-11
Greenland Shelf (1F)	0.0	1.1	-0.6	2.1	0.1	0.9	-0.7	-0.6	0.9	0.2	-1.2	-1.1	-1.0	3.8	-0.5	-0.7	-1.0	1.9	4.3	-59	112
Central Labrador Sea (2GH,1F)	-0.4	-0.9	-0.6	1.0	0.4	-0.2	-0.5	-0.3	0.0	-0.2	2.9	-0.8	-0.4	-0.1	0.3	-0.8	1.4	17.4	1.4	104	1266
Bravo (2H,1F)	-0.4	-0.5	-0.4	-0.3	-0.1	-0.2	-0.4	-0.3	-0.3	0.2	3.3	-0.4	-0.2	-0.1	0.6	-0.5	0.8	5.4	1.8	121	861
Northern Labrador Shelf (2H)	-0.4	0.1	-0.2	-0.5	-0.8	0.0	-0.5	1.0	-0.2	-0.7	0.1	2.9	-0.7	-0.1	-0.6	-1.5	-0.3	4.4	1.2	-19	245
Labrador Shelf (2J)	1.4	1.5	-0.7	-0.7	-1.3	0.5	-0.5	-0.8	-0.7	-1.1	0.9	0.5	1.2	-0.3	-0.6	-0.9	0.0	2.4	1.9	-2	115
Hamilton Bank (2J)	-0.7	1.3	-1.0	-0.5	-0.9	0.3	-0.9	-0.6	0.5	-0.7	2.1	0.1	1.0	-0.3	0.1	-0.7	-0.5	1.8	2.1	-28	110
St. Anthony Basin (3K)	-0.5	0.5	-1.1	0.8	1.8	-0.4	-0.8	-1.2	-0.2	-0.4	1.6	0.6	-0.8	2.2	-0.8	-0.5	-0.9	2.3	2.6	-52	135
Northeast Newfoundland Shelf (3KL)	-0.5	-0.7	0.0	-1.2	0.4	-0.5	-0.7	-0.4	1.9	2.1	-0.8	0.0	0.3	4.0	-0.7	-0.6	-0.9	0.6	2.7	-51	35
Northwest Gulf of St. Lawrence (4S)	1.1	-0.1	-1.2	1.3	1.7	-0.2	0.3	0.9	-0.2	-0.7	-0.3	-1.6	-1.0	-1.5	0.2	-0.4	-0.4	1.1	5.0	-12	33
Northeast Gulf of St. Lawrence (4RS)	2.4	-0.3	-0.6	0.6	-0.8	-0.7	0.3	-1.2	-0.1	0.1	-0.9	-0.2	1.4	2.7	-0.8	1.3	-1.0	-1.2	1.5	-48	-61
GSL Estuary (4T)	0.1	1.1	-0.6	0.0	0.0	-0.4	-0.2	-0.5	-0.5	-0.5	2.9	-0.6	-0.9	-0.6	-0.7	1.5	-0.4	-2.4	9.9	-18	-25
Cabot Strait (3Pn, 4Vn)	1.1	1.0	0.3	-0.7	-0.4	0.6	-0.4	-1.3	1.7	0.8	-1.3	-0.3	-1.1	0.1	-0.2	-0.5	0.3	-1.1	3.5	18	-64
Magdalen Shallows (4T)	0.3	-1.4	-1.1	-0.2	0.4	-0.7	1.1		-0.3	0.5	-1.0	2.2	0.2	6.6	2.9	-1.3	1.3	8.7	2.8	43	279
Avalon Channel (3L)	-1.0	-0.6	-0.5	-0.7	-0.6	-0.1	-0.6	-0.9	0.6	0.9	0.0	1.0	2.5	1.1	0.4	-0.1	-0.4	-0.7	2.5	-27	-50
Hibernia (3L)	-0.7	1.4	1.4	-1.0	-0.8	-1.3	-0.1	-1.0	0.1	0.0	1.8	0.2	0.0	0.7	-0.8	-0.9	-0.4	-1.0	4.3	-26	-65
Flemish Pass (3LM)	-0.9	-0.1	-0.4	-1.4	2.0	-0.3	-1.0	0.9	0.0	1.2	0.3	0.7	-1.0	0.0	1.6	-0.1	-0.5	-1.5	2.3	-22	-68
Flemish Cap (3M)						0.4	-0.6	-0.4	2.1	-1.0	0.6	-0.3	-0.8	0.1	2.1	0.1	1.1	-0.2	2.6	60	-12
St. Pierre Bank (3Ps)	-0.4	0.4	-1.0	2.1	-0.7	-0.3	-0.3	1.0	1.5	-0.2	-1.4	-0.1	-0.6	-0.1	4.7	-1.1	-0.4	-2.0	2.1	-15	-82
Southeast Shoal (3NO)	-0.9	0.1	-1.5	0.3	1.2	0.1	-0.9	-1.3	0.5	-0.3	1.9	-0.1	0.9	-1.1	-0.4	0.8	0.8	-1.3	3.3	38	-67
Eastern Scotian Shelf (4Vs)	1.5	-0.6	-0.1	-1.1	0.9	0.3	-0.6	-1.3	1.6	0.7	-0.2	-1.5	0.3	1.7	2.1	2.7	-1.2	-1.1	3.1	-49	-45
Western Bank (4W)	-0.5	-0.5	-0.9	-0.4	-0.1	0.3	0.4	-0.6	-0.2	2.9	-1.1	0.4	0.2	2.2	-0.2	-1.0	-0.9	1.2	1.6	-61	84
Central Scotian Shelf (4W)	-1.2	-0.7	0.8	-1.2	0.5	1.3	-0.1	-0.9	-0.5	1.8	0.3	0.8	-1.0	-0.3	6.6	-0.5	-0.3	2.3	2.1	-14	125
Western Scotian Shelf (4X)	-0.6	-0.4	-0.7	-0.4	0.1	3.0	-0.7	0.6	0.7	-0.5	-0.5	0.0	-0.3	-0.6		-0.6	-0.6	-0.3	4.4	-77	-39
Lurcher Shoal (4X)	-0.6	-0.9	-1.2	2.6	-0.7	0.9	-0.3	-0.8	0.8	-0.2	-0.3	-0.4	-0.1			-0.9		0.0	1.3	-100	-3
Georges Bank (5Ze)	-0.6	-0.6	-0.1	3.2	-0.6	0.2	0.0	-0.5	-0.2	-0.6	-0.4	0.1	0.1	0.3	-0.5	-0.5	-0.4	-0.3	5.5	-54	-36

Fig. 9. Annual anomalies of the amplitude (peak intensity in mg m^{-3}) of the spring bloom derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2015. Blue cells indicate lower than normal levels and red cells indicate higher than normal levels. More intense colours indicate larger standardized anomalies and large changes (> 10 SD) shown in yellow. The numbers in the coloured cells are the differences between a given year and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells). The unstandardized mean during 1998-2010 is provided along with % differences between reference period and 2014 and 2015 respectively.

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1998-2010 Mean ± SD	% Difference in 2014	% Difference in 2015
Hudson Strait (0B, 2G)	0.4	-0.3	0.6	-0.7	-0.1	2.4	-0.7	-1.2	-0.7	0.9	-1.2	0.1	0.5	-0.1	-0.5	-0.2	-1.8	0.1	209	-18	1
Greenland Shelf (1F)	0.8	1.7	0.1	0.5	-0.4	0.4	-0.9	-2.0	-0.4	0.0	0.0	1.2	-1.0	-0.3	0.2	-0.5	0.5	0.3	138	4	2
Central Labrador Sea (2GH,1F)	-0.9	0.1	1.1	-0.9	0.6	-0.6	1.2	1.5	-1.3	-0.9	-1.1	0.2	1.0	-1.5	-0.9	-1.0	-1.2	-1.6	163	-11	-16
Bravo (2H,1F)	1.2	0.7	0.1	0.2	-0.3	-0.7	-0.4	0.5	0.5	-0.9	-2.4	0.1	1.5	0.0	-1.9	1.8	-1.9	-2.4	178	-17	-23
Northern Labrador Shelf (2H)	-0.4	-0.1	0.1	-0.4	0.8	-0.7	-0.3	-0.4	-0.4	2.8	-1.4	0.3	0.1	-0.4	-0.2	-0.1	-0.1	-0.5	169	-2	-11
Labrador Shelf (2J)	-0.2	-0.4	1.0	1.4	1.5	-0.1	-0.1	-0.5	-1.5	1.0	-1.1	0.5	-1.4	-0.3	-0.8	-0.7	-2.4	-0.6	155	-23	-6
Hamilton Bank (2J)	-0.5	-0.2	1.1	0.8	1.6	0.2	-0.1	-0.5	-1.8	0.8	-1.2	0.7	-1.0	-0.3	-0.9	-0.1	0.4	-0.3	151	5	-3
St. Anthony Basin (3K)	-0.2	-0.7	-1.0	0.1	0.2	1.8	0.8	0.1	-0.1	0.4	-1.1	-1.7	1.4	1.1	1.5	2.0	1.7	1.6	108	24	23
Northeast Newfoundland Shelf (3KL)	-0.3	-1.2	0.2	1.4	1.3	1.2	0.7	-0.9	-1.0	0.0	0.6	-0.3	-1.6	0.0	-0.7	0.2	0.8	1.2	120	7	11
Northwest Gulf of St. Lawrence (4S)	-0.6	1.0	1.6	0.1	0.5	0.8	0.7	-1.5	-0.4	0.0	0.1	-0.4	-2.0	-1.1	-0.9	-0.3	-0.1	0.0	139	-1	-1
Northeast Gulf of St. Lawrence (4RS)	-0.6	0.1	1.2	0.1	0.8	2.4	-0.7	0.0	-0.9	0.0	-0.1	-0.8	-1.5	-0.4	-0.7	-1.2	0.0	0.3	128	0	4
GSL Estuary (4T)	-0.8	-0.4	-0.9	0.7	0.3	0.2	0.5	0.3	-0.3	-0.6	2.7	-0.8	-1.0	-1.7	-1.3	0.3	-2.2	-7.1	185	-31	-16
Cabot Strait (3Pn, 4Vn)	-0.7	-1.5	-0.4	1.2	0.1	0.7	0.6	0.4	-0.6	0.4	1.5	0.3	-2.0	0.8	-0.7	0.3	0.5	1.7	107	7	22
Magdalen Shallows (4T)	0.5	-1.2	1.0	1.3	0.1	-0.1	0.1		0.2	0.0	0.2	0.4	-2.5	-1.2	-2.6	-1.8	-0.4	0.3	119	-3	3
Avalon Channel (3L)	0.0	-1.2	-0.5	1.1	0.4	2.1	-0.2	-0.9	0.3	0.0	1.0	-0.9	-1.3	0.1	-0.7	0.3	1.0	2.2	109	9	19
Hibernia (3L)	0.7	-0.9	-0.9	0.9	1.7	0.4	-0.3	0.2	0.1	0.1	0.9	-0.8	-2.1	0.3	-0.5	-0.6	0.6	1.9	107	6	20
Flemish Pass (3LM)	-0.3	-1.7	0.2	1.1	1.1	1.8	0.2	-0.8	-1.4	-0.2	-0.2	-0.3	0.6	-0.1	-0.6	-0.9	-0.5	0.2	126	-6	2
Flemish Cap (3M)						2.0	0.8	-0.9	-0.8	-0.5	-0.3	-0.8	0.5	1.2	-0.8	-1.1	-1.0	0.4	128	-10	4
St. Pierre Bank (3Ps)	-0.1	0.9	-0.3	0.4	0.2	1.3	0.3	-0.7	0.2	-0.2	0.6	0.2	-2.8	-0.5	-1.2	0.0	0.6	-0.1	114	5	-1
Southeast Shoal (3NO)	0.2	-0.4	-0.8	0.5	0.7	1.6	0.7	0.0	-0.1	0.7	0.6	-2.1	-1.5	-0.7	-0.3	0.0	0.2	1.7	102	2	23
Eastern Scotian Shelf (4Vs)	-0.1	-1.7	0.5	1.5	0.2	0.9	0.8	-1.0	-0.5	-0.2	0.2	1.1	-1.7	0.0	-2.1	1.1	1.0	1.1	100	9	10
Western Bank (4W)	0.1	-2.7	1.5	-0.1	0.4	0.4	0.5	-0.2	-0.9	1.0	0.3	0.0	-0.3	-2.0	0.0	2.4	1.7	2.0	79	21	25
Central Scotian Shelf (4W)	-0.6	-2.1	1.9	0.9	0.0	0.8	0.2	-0.4	-0.6	0.2	0.1	0.6	-1.0	0.9	-1.7	1.3	3.5	2.0	92	29	17
Western Scotian Shelf (4X)	-0.5	-2.1	1.3	1.6	-0.7	0.7	-0.4	-0.7	-0.4	0.7	0.7	0.3	-0.5	1.0		-4.2	0.1	1.7	97	1	14
Lurcher Shoal (4X)	-0.3	-0.8	-6.8	0.8	-2.2	0.4	0.8	0.5	-0.2	0.1	1.6	0.4	-1.0			0.1		2.2	99	-100	33
Georges Bank (5Ze)	0.0	-1.9	-1.8	1.2	1.4	0.3	0.0	0.6	-0.8	0.0	0.0	0.1	0.9	0.0	-0.3	1.9	-1.2	2.0	101	-15	26

Fig. 10. Annual anomalies of the peak timing (day of year) of the spring bloom derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2015. Blue cells indicate earlier and red cells indicate later than normal blooms. More intense colours indicate larger standardized anomalies and large changes (± 5 SD) shown in yellow. The numbers in the coloured cells are the differences between a given year and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells). The unstandardized mean during 1998-2010 is provided along with % differences between reference period and 2014 and 2015 respectively.

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1998-2010 Mean ± SD	% Difference in 2014	% Difference in 2015
Hudson Strait (0B, 2G)	0.7	-1.0	-0.3	-1.2	-0.2	2.3	0.2	0.1	1.1	0.0	-1.0	-1.2	0.5	0.2	0.2	-0.1	-1.4	-1.0	158.5	-65	-43
Greenland Shelf (1F)	-0.3	-0.6	0.2	-0.6	1.0	-0.8	-0.4	-1.2	-0.2	0.6	-1.1	0.8	2.4	-1.7	0.2	0.1	-0.8	1.7	39.5	-30	58
Central Labrador Sea (2GH,1F)	0.1	1.2	-0.7	-1.4	-1.1	0.5	0.9	1.2	-1.0	0.9	-1.2	-0.5	1.0	2.8	-0.9	-0.9	-1.3	-1.4	101.6	-76	-79
Bravo (2H,1F)	1.1	0.4	-0.6	0.1	-1.0	0.0	1.1	0.4	0.4	-1.4	-1.5	-0.9	1.7	-1.3	-1.3	-1.3	-1.4	-1.3	116.1	-86	-80
Northern Labrador Shelf (2H)	0.3	-0.3	-0.7	1.3	-0.6	0.6	-0.4	-0.9	-0.1	0.2	2.4	-1.3	-0.8	-0.9	-0.3	-0.7	-0.9	-1.3	55.3	-49	-68
Labrador Shelf (2J)	-1.1	-0.6	-0.1	0.7	1.3	-0.7	-1.3	0.7	2.0	-0.8	0.5	-0.5	-0.3	-0.3	-0.4	-0.4	-0.6	-0.3	42.1	-28	-15
Hamilton Bank (2J)	0.6	-1.0	0.4	2.3	0.7	-1.0	0.3	0.6	-0.3	-0.7	-1.4	0.2	-0.7	-0.8	-0.5	-1.0	-1.0	-1.6	54.8	-39	-63
St. Anthony Basin (3K)	0.6	-0.1	-1.0	-1.0	-0.6	-0.1	0.3	0.5	-0.3	-1.2	2.6	-0.3	0.7	-0.9	0.5	-1.5	-1.9	-1.9	49.5	-61	-59
Northeast Newfoundland Shelf (3KL)	0.8	1.4	0.4	-0.3	-0.6	-0.3	0.0	-0.8	-0.5	-1.6	0.2	2.2	-0.9	-0.7	-0.4	-1.3	-0.2	-1.6	46.9	-6	-65
Northwest Gulf of St. Lawrence (4S)	-0.3	-0.3	1.5	-0.5	-2.3	0.8	0.9	-0.9	0.7	-0.4	1.1	-0.1	-0.1	-0.7	3.3	0.1	0.9	2.7	52.9	23	71
Northeast Gulf of St. Lawrence (4RS)	-1.1	-1.1	-0.8	-1.1	0.4	1.0	-0.2	2.3	-0.3	-0.1	1.1	-0.1	0.0	-2.1	1.1	-0.9	-1.3	-2.2	50.1	-39	-66
GSL Estuary (4T)	-1.1	-0.4	-1.2	0.6	0.6	0.6	0.2	0.0	0.4	-0.5	2.5	-1.1	-0.5	-1.2	-0.2	1.0	-1.0	-1.6	172.4	-63	-50
Cabot Strait (3Pn, 4Vn)	-0.1	-1.5	-1.0	-0.6	2.3	-0.8	-0.8	1.0	0.5	0.4	-0.3	0.5	0.5	-0.3	6.0	0.6	-0.7	-1.3	35.0	-13	-25
Magdalen Shallows (4T)	-0.5	-0.4	2.1	-0.2	0.3	1.1	-1.3		-1.3	0.6	-0.2	-0.8	0.6	-1.7	0.1	1.3	-0.7	-1.7	42.6	-25	-64
Avalon Channel (3L)	-0.1	0.1	-0.3	1.4	1.6	-0.6	0.8	1.5	-0.9	-1.1	-0.7	-0.7	-1.1	-1.0	-1.6	-0.8	-0.8	-1.1	41.6	-27	-37
Hibernia (3L)	0.4	-0.1	-0.1	0.3	2.1	1.2	1.1	-0.5	-1.0	-0.8	-1.1	-0.1	-1.3	-1.5	-0.8	2.0	-0.4	-1.3	44.9	-12	-37
Flemish Pass (3LM)	-0.3	-0.5	0.0	1.2	-0.7	-0.2	1.5	-0.6	-0.4	-1.0	-1.0	-0.2	2.2	-1.1	-1.3	-0.3	-1.0	-1.1	60.4	-49	-54
Flemish Cap (3M)						-0.1	0.7	0.9	-0.7	-0.8	-1.0	-0.7	1.7	-1.0	-1.1	-0.3	-1.1	-1.3	67.6	-63	-75
St. Pierre Bank (3Ps)	-0.6	-0.8	-0.4	-0.4	0.4	-0.6	0.1	-1.1	-1.0	-0.2	0.8	1.6	2.1	0.5	-1.2	-0.3	-0.3	0.8	36.7	-13	31
Southeast Shoal (3NO)	1.7	0.6	-0.6	-0.7	0.0	-1.1	0.1	1.0	-0.5	-1.3	-0.2	1.7	-1.0	5.7	-1.2	-0.2	1.4	-1.1	40.0	40	-29
Eastern Scotian Shelf (4Vs)	-0.5	-0.9	0.1	-0.7	-0.5	-0.8	-0.2	0.1	-0.8	1.4	1.6	1.9	-0.8	-0.5	0.0	-1.1	-0.7	0.1	38.5	-23	2
Western Bank (4W)	0.2	0.1	1.5	0.9	-0.3	0.9	-0.3	-1.2	-0.7	-1.3	-0.1	1.6	-1.2	2.0	-0.9	1.5	7.2	0.0	33.6	218	-1
Central Scotian Shelf (4W)	0.4	0.6	-0.4	2.9	-0.5	-0.4	-0.6	-0.8	0.5	-0.6	-0.6	-0.5	0.0	-0.4	-1.6	-0.4	-0.4	-1.0	39.0	-19	-46
Western Scotian Shelf (4X)	0.6	-0.2	0.5	-0.4	-0.6	-1.2	-0.7	-0.5	-0.6	2.0	2.0	-0.3	-0.5	0.4		2.2	0.3	-0.3	28.9	17	-17
Lurcher Shoal (4X)	-0.7	-0.5	-1.0	-0.6	1.8	-0.5	-0.6	-0.6	-0.5	-0.3	-0.5	0.9	2.0			0.0		0.2	50.3	-100	16
Georges Bank (5Ze)	-0.7	0.7	-0.7	-1.1	2.8	-0.2	-0.1	-0.2	-0.5	-0.1	-0.4	1.0	-0.4	0.0	-0.4	-0.7	-0.4	-0.6	44.6	-35	-47

Fig. 11. Annual anomalies of the duration (in days) of the spring bloom derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2014. Blue cells indicate lower duration and red cells indicate higher than normal duration of blooms. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between a given year and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

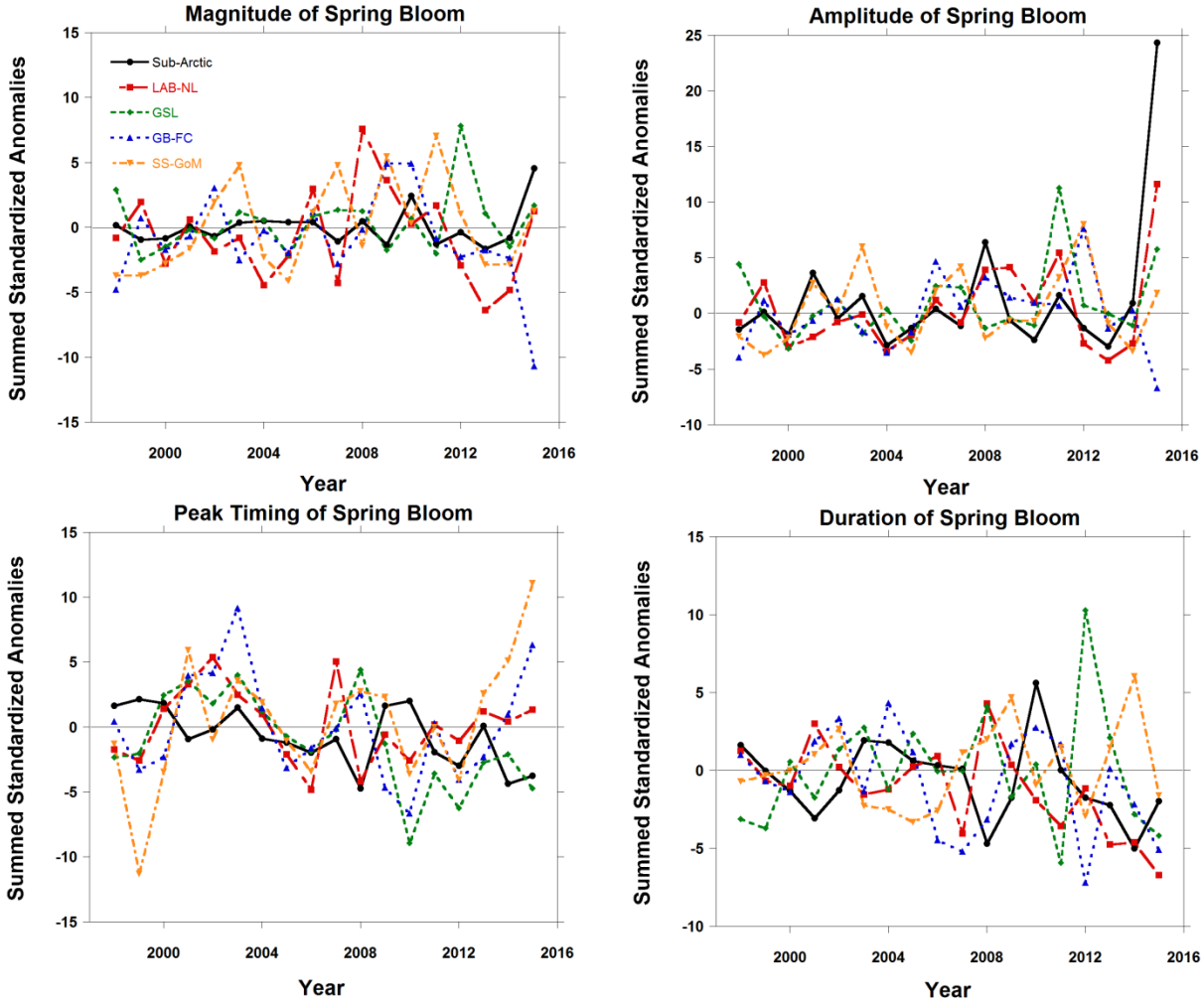

Fig. 12. Composite (sum of anomalies) annual anomalies across the Sub-Arctic (Greenland Shelf, Hudson Strait, Central Labrador Sea, Bravo); Labrador (LAB) and Newfoundland (NL) Shelf (Northern Labrador Shelf, Labrador Shelf, Hamilton Bank, St. Anthony Basin, northeast Newfoundland Shelf); Gulf of St. Lawrence (GSL) (NE and NW Gulf of St. Lawrence, Estuary, and Magdalen Shallows, Cabot Strait); Grand Bank (GB) and Flemish Cap (FC) (Avalon Channel, Hibernia, Flemish Pass/Cap, St. Pierre Bank and SE Shoal) and Scotian Shelf (SS) and Gulf of Maine (GoM) (Eastern-Central-Western Scotian Shelf, Western Bank, Lurcher Shoal, Georges Bank) for the different ocean colour metrics during 1998-2015.

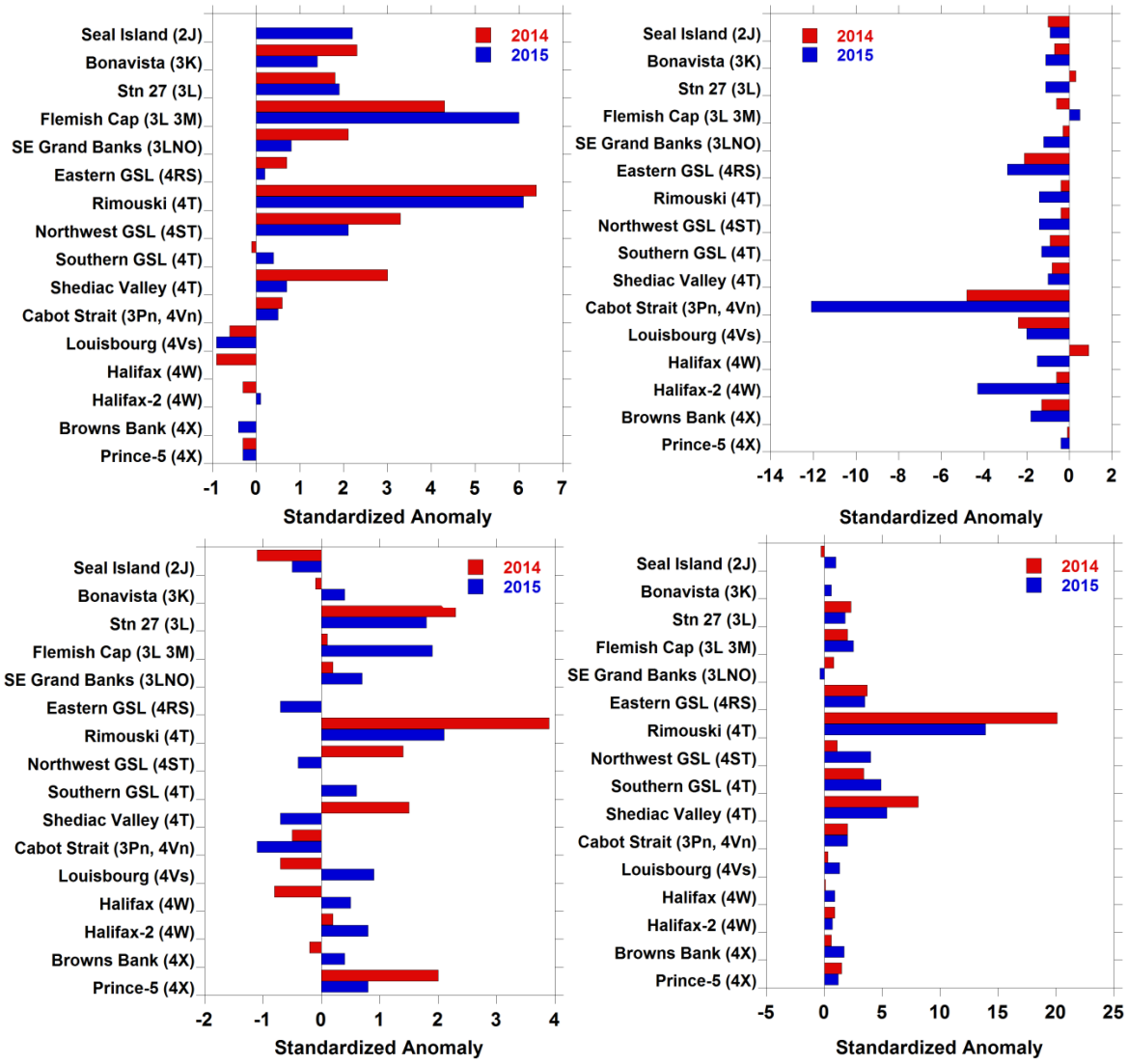

Fig. 13. Summary of zooplankton abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2014 and 2015. *Pseudocalanus* spp. (top left panel) and *Calanus finmarchicus* (top right panel) represent dominant and ecological important copepod taxa in the northwest Atlantic. The bottom panels show total copepod (dominant taxa) and non-copepod taxa respectively. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from the southern Labrador Shelf - 2J (top) to southern Scotian Shelf - 4X (bottom).

Pseudocalanus spp.	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Seal Island (2J)	0.0	-0.5	0.2	-0.6	0.2	-0.3	-0.7	0.7	1.6	1.5	-2.1	-0.2	0.8	1.8	-0.8	0.0	2.2
Bonavista (3K)	-1.2	-1.8	1.1	0.0	0.5	0.0	-1.0	0.6	-0.5	-0.1	0.9	1.5	-0.6	-0.1	2.8	2.3	1.4
Stn 27 (3L)	-0.6	0.8	0.3	0.5	0.3	-1.7	-0.2	-0.8	0.5	-1.5	1.7	0.8	0.2	0.2	0.7	1.8	1.9
Flemish Cap (3L 3M)	-0.2	1.5	-0.3	1.5	-0.5	-0.8	-1.4	0.0	-0.7	-0.6	-0.1	1.7	-1.6	-0.3	3.4	4.3	6.0
SE Grand Banks (3LNO)	-2.5	1.2	0.5	0.8	-0.7	-0.1	0.7	-0.6	0.5	-0.6	0.0	0.7	1.4	-0.6	1.5	2.1	0.8
Eastern GSL (4RS)		2.5	-1.1	-0.8	-0.4	0.7	-0.4	-0.3	-0.9	0.2	-0.1	0.5	0.7	-0.7	-0.3	0.7	0.2
Rimouski (4T)							-1.2	-0.4	0.7	-0.7	0.1	1.6	1.6	-1.1	-0.4	6.4	6.1
Northwest GSL (4ST)		0.4	-1.6	-0.6	-1.0	-0.1	-0.9	0.7	1.0	-0.3	0.7	1.8	0.5	-1.4	1.1	3.3	2.1
Southern GSL (4T)		0.8	-0.9	-0.9	-0.2	0.2	-1.2	0.8	-1.1	-0.3	0.6	2.1	0.3	-0.4	0.9	-0.1	0.4
Shediac Valley (4T)	1.4	-0.9	2.0	-0.2	0.0	-0.6	0.4	-1.6	-0.9	-0.3	0.1	0.5	1.0	-0.2	-0.4	3.0	0.7
Cabot Strait (3Pn, 4Vn)	0.3	-0.4	-1.2	-1.1	1.3	1.2	0.5	0.8	-1.9	0.0	-0.1	0.6	-0.3	-1.5	-0.6	0.6	0.5
Louisbourg (4Vs)	1.7	-1.5	0.9	1.4	0.2	0.4	-0.2	-0.6	-1.3	-0.1	-1.0	0.1	0.0	-5.3	-1.3	-0.6	-0.9
Halifax (4W)	0.4	0.8	0.4	1.3	0.2	-0.4	-0.4	-2.4	0.3	0.6	0.6	-1.2	-1.1	-1.4	0.9	-0.9	0.0
Halifax-2 (4W)	0.8	0.8	0.0	-0.5	1.1	0.9	-1.8	-1.3	0.1	0.9	0.3	-1.3	-0.7	-1.7	0.4	-0.3	0.1
Browns Bank (4X)	0.4	0.9	1.3	0.0	0.6	-0.9	-0.1	-1.1	0.3	1.0	-0.2	-2.2	-1.5	-2.7	0.2	0.0	-0.4
Prince-5 (4X)	-1.5	0.3	1.8	-1.4	0.2	0.1	-1.0	-0.4	0.3	1.2	-0.4	0.8	0.4	0.0	0.6	-0.3	-0.3

Calanus finmarchicus	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Seal Island (2J)	0.1	-2.0	-0.7	0.1	0.2	1.4	1.2	0.4	0.5	0.0	-1.6	0.4	1.0	0.2	0.2	-1.0	-0.9
Bonavista (3K)	-1.9	-1.9	-0.2	0.1	0.2	1.0	0.1	1.4	0.7	0.0	0.1	0.4	0.0	0.3	1.1	-0.7	-1.1
Stn 27 (3L)	1.1	0.4	0.1	0.5	0.0	-0.7	0.0	-0.2	-0.1	-2.7	0.3	1.3	0.5	-0.5	-1.9	0.3	-1.1
Flemish Cap (3L 3M)	-1.0	-2.5	0.6	0.7	0.0	-0.2	0.5	1.1	-0.2	0.1	-0.1	1.1	1.1	1.3	0.0	-0.6	0.5
SE Grand Banks (3LNO)	-2.4	-1.5	0.2	0.7	0.5	0.0	0.8	0.0	0.2	0.0	0.6	0.8	1.1	0.3	0.4	-0.3	-1.2
Eastern GSL (4RS)		0.9	-1.1	-0.2	0.4	1.2	-0.4	-0.5	1.3	0.9	-1.1	-1.5	-0.4	-0.1	-1.0	-2.1	-2.9
Rimouski (4T)							-0.9	0.0	1.8	0.3	-0.2	-0.9	-0.8	-0.6	-1.0	-0.4	-1.4
Northwest GSL (4ST)		-0.2	-0.9	-0.4	0.5	-0.2	-0.6	2.2	1.5	-0.4	-0.8	-0.9	-0.8	-0.6	-0.6	-0.4	-1.4
Southern GSL (4T)		-1.4	0.0	1.0	0.1	0.4	-1.0	1.0	0.1	1.8	-1.0	-1.0	-1.4	0.4	-0.7	-0.9	-1.3
Shediac Valley (4T)	-0.6	-0.3	-0.3	-0.3	2.6	1.3	-0.5	0.1	-0.4	0.2	-0.9	-0.9	-1.1	-0.3	-1.0	-0.8	-1.0
Cabot Strait (3Pn, 4Vn)	1.7	-0.2	-1.5	-0.5	0.6	1.4	-0.3	0.4	0.1	0.2	-1.6	-0.4	-2.7	-1.6	-3.8	-4.8	-12.1
Louisbourg (4Vs)	1.0	-1.4	-0.8	2.1	-1.1	-0.1	-0.1	0.3	-0.6	0.3	-0.7	0.9	-1.8	-3.9	-2.3	-2.4	-2.0
Halifax (4W)	-1.3	-0.8	-1.1	1.0	1.1	-0.5	-0.2	-0.5	-0.8	0.9	1.7	0.6	0.0	-1.8	1.1	0.9	-1.5
Halifax-2 (4W)	1.1	1.2	1.0	-1.7	0.3	-0.2	-1.3	-0.7	-0.5	1.1	-0.6	0.4	-2.6	-4.2	-1.2	-0.6	-4.3
Browns Bank (4X)	-0.5	-0.7	1.0	0.5	1.4	-1.6	-0.5	0.8	-0.8	0.6	1.0	-1.2	-1.4	-2.7	0.3	-1.3	-1.8
Prince-5 (4X)	-2.2	-1.3	0.1	-0.8	0.5	0.9	0.7	1.5	0.2	0.5	-0.1	0.0	0.0	-0.6	-0.1	-0.1	-0.4

Fig. 14. Time series of dominant copepods *Pseudocalanus spp*. (top panel), and *Calanus finmarchicus* (lower panel) abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2015. The copepod abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. A empty grey cell indicates missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. Large standardized anomalies values > ± 10 shown in yellow. The numbers in the coloured cells are the differences from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) Subareas.

Total Copepods	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seal Island (2J)	-0.9	-1.9	-0.8	0.0	0.4	1.5	1.2	1.3	0.2	-0.4	-0.6	0.0	0.0	-0.9	0.2	-1.1	-0.5
Bonavista (3K)	-1.8	-1.7	-0.4	-0.7	0.4	0.3	-0.3	1.2	0.5	0.4	0.8	1.1	0.1	-1.2	1.5	-0.1	0.4
Stn 27 (3L)	-0.5	0.3	-0.5	0.5	0.1	-1.1	-0.1	-1.3	0.5	-1.2	2.1	1.2	1.1	-0.3	0.0	2.3	1.8
Flemish Cap (3L 3M)	-1.4	-1.3	0.0	-0.4	-0.9	-0.5	0.4	1.1	0.2	0.4	0.5	2.0	0.2	0.8	0.7	0.1	1.9
SE Grand Banks (3LNO)	-2.5	0.4	-1.1	-0.1	-0.1	0.1	1.0	-0.3	0.8	0.1	0.9	1.0	1.6	1.1	-0.2	0.2	0.7
Eastern GSL (4RS)		2.1	-2.0	0.1	-0.1	0.7	-0.8	-0.5	0.0	0.4	-0.1	0.3	0.5	-0.7	-1.0	0.0	-0.7
Rimouski (4T)							-1.5	-0.7	1.0	-0.2	1.2	0.2	1.4	-0.4	-0.4	3.9	2.1
Northwest GSL (4ST)		0.1	-1.7	-1.0	-1.2	-0.5	-0.2	1.4	0.4	0.9	0.4	1.3	-0.3	-1.4	-1.2	1.4	-0.4
Southern GSL (4T)		-0.7	-0.3	0.5	-0.8	-0.8	-1.8	1.0	-0.2	1.6	1.1	0.3	0.0	0.2	-1.8	0.0	0.6
Shediac Valley (4T)	0.7	-0.8	0.0	-0.6	0.8	-0.5	-0.2	-0.8	0.2	2.6	-0.8	-0.5	-0.3	-0.5	-1.7	1.5	-0.7
Cabot Strait (3Pn, 4Vn)	2.1	-0.6	-2.0	-0.9	0.3	0.6	0.0	0.0	0.0	0.6	-0.4	0.4	-1.1	-1.1	-1.9	-0.5	-1.1
Louisbourg (4Vs)	2.4	-0.4	-0.3	-1.5	0.6	-0.4	0.3	-0.1	-0.8	0.6	-1.0	0.5	-0.5	-0.7	-2.1	-0.7	0.9
Halifax (4W)	2.1	1.1	0.1	-0.6	-0.2	-1.2	0.8	-1.1	-0.3	-0.2	0.7	-1.1	-1.0	-0.8	-1.4	-0.8	0.5
Halifax-2 (4W)	1.4	1.3	0.5	-1.9	0.0	0.3	0.7	-0.8	-1.2	0.1	0.3	-0.8	-0.7	-1.7	-0.7	0.2	0.8
Browns Bank (4X)	1.2	1.1	0.7	0.9	0.8	-1.4	-0.8	0.2	-1.3	0.3	-0.8	-1.0	-1.8	0.5	-0.2	-0.2	0.4
Prince-5 (4X)	0.7	0.3	1.7	-1.7	-0.2	-0.1	-1.4	0.7	-0.5	0.1	-0.8	1.2	-0.5	0.7	0.8	2.0	0.8

Non-copepods	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Seal Island (2J)	-1.6	-0.7	-0.2	-0.7	-0.1	1.2	1.0	2.0	0.1	-1.0	-0.1	0.2	0.1	-1.0	0.7	-0.3	1.0
Bonavista (3K)	-1.5	-1.9	0.2	0.1	0.3	-0.3	-0.1	1.6	0.0	-0.3	1.1	1.1	-0.4	-0.6	1.8	0.0	0.6
Stn 27 (3L)	-0.5	0.3	-0.5	0.5	0.1	-1.1	-0.1	-1.3	0.5	-1.2	2.1	1.2	1.1	-0.3	0.0	2.3	1.8
Flemish Cap (3L 3M)	-2.0	0.1	0.4	0.7	-0.8	-0.8	0.0	0.3	-0.4	0.2	0.1	2.2	0.6	1.9	2.6	2.0	2.5
SE Grand Banks (3LNO)	-2.5	1.5	0.4	0.1	-0.1	-0.5	0.5	0.0	-0.5	-0.1	0.0	1.3	0.5	1.2	0.4	0.8	-0.4
Eastern GSL (4RS)		-0.6	-1.4	-0.7	-1.1	0.3	1.7	1.3	1.1	-0.1	0.0	-0.4	4.4	-0.3	1.7	3.7	3.5
Rimouski (4T)							-1.0	-0.7	1.3	-1.0	0.5	0.9	1.9	-1.1	2.5	20.1	13.9
Northwest GSL (4ST)		-0.6	-0.9	-0.8	-0.3	-0.7	-0.6	1.4	2.2	0.6	-0.1	-0.1	1.2	-0.3	-0.4	1.1	4.0
Southern GSL (4T)		-0.7	-0.9	-0.3	-0.7	-0.8	0.5	-0.2	0.1	-0.1	0.2	2.7	1.9	1.7	2.4	3.4	4.9
Shediac Valley (4T)	1.9	-1.2	0.7	-0.1	-1.2	-0.8	0.8	0.4	0.2	1.0	-1.2	-0.6	0.2	4.4	0.3	8.1	5.4
Cabot Strait (3Pn, 4Vn)	1.5	-0.7	-1.3	-1.9	-0.4	1.0	0.5	1.2	0.0	0.3	0.2	-0.3	0.5	-1.2	0.2	2.0	2.0
Louisbourg (4Vs)	1.3	-0.9	1.4	0.0	-0.9	0.1	0.7	0.7	-0.8	0.8	-1.9	-0.4	1.2	-1.8	0.4	0.3	1.3
Halifax (4W)	1.6	1.4	-1.8	0.0	0.9	0.1	0.4	-0.8	0.0	-0.5	-0.1	-1.1	0.4	0.7	0.0	0.1	0.9
Halifax-2 (4W)	2.5	0.8	-0.5	-1.2	-0.2	0.7	0.1	-0.8	-0.8	0.5	-0.4	-0.6	0.8	0.2	0.5	0.9	0.7
Browns Bank (4X)	1.7	1.4	0.3	-0.5	1.1	-0.8	-1.2	-0.6	-0.6	0.5	-1.2	0.1	-1.3	1.8	0.1	0.6	1.7
Prince-5 (4X)	1.3	1.2	1.4	0.5	-0.5	0.2	-1.1	-1.4	0.2	-0.5	-1.4	0.2	-0.4	0.7	0.9	1.5	1.2

Fig. 15. Time series of total copepod (top panel) and non-copepod (lower panel) abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2015. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. A grey cell indicates missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. Large standardized anomalies values > ± 10 shown in yellow. The numbers in the coloured cells are the differences from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) Subareas.

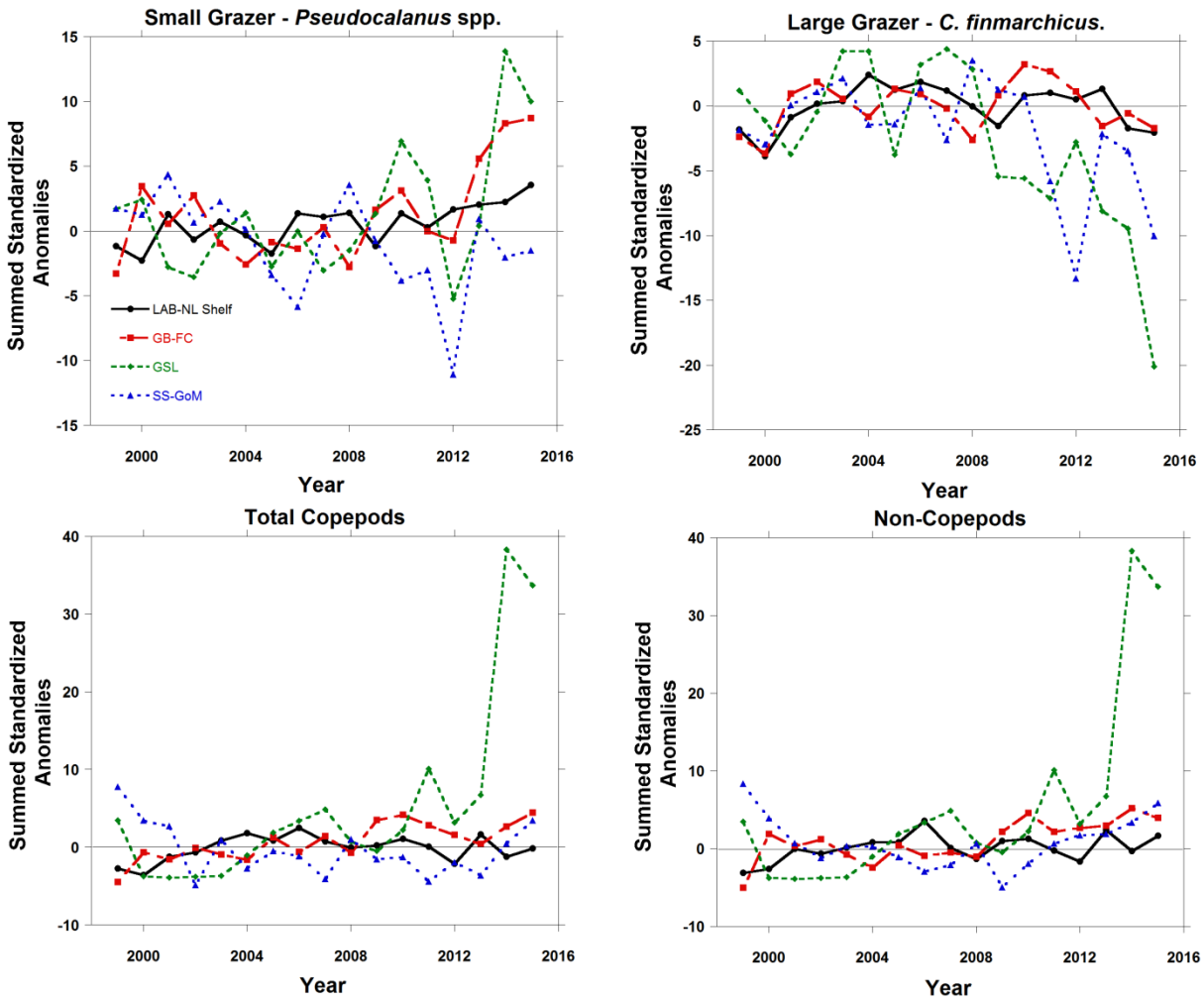

Fig. 16. Composite sums of annual anomalies across the Labrador and northeast Newfoundland Shelf (LAB-NL Shelf), Grand Bank-Flemish Cap (GB-FC), Gulf of St. Lawrence (GSL), and Scotian Shelf – Gulf of Maine (SS-GoM) for the different functional zooplankton abundance indices during 1999-2015.

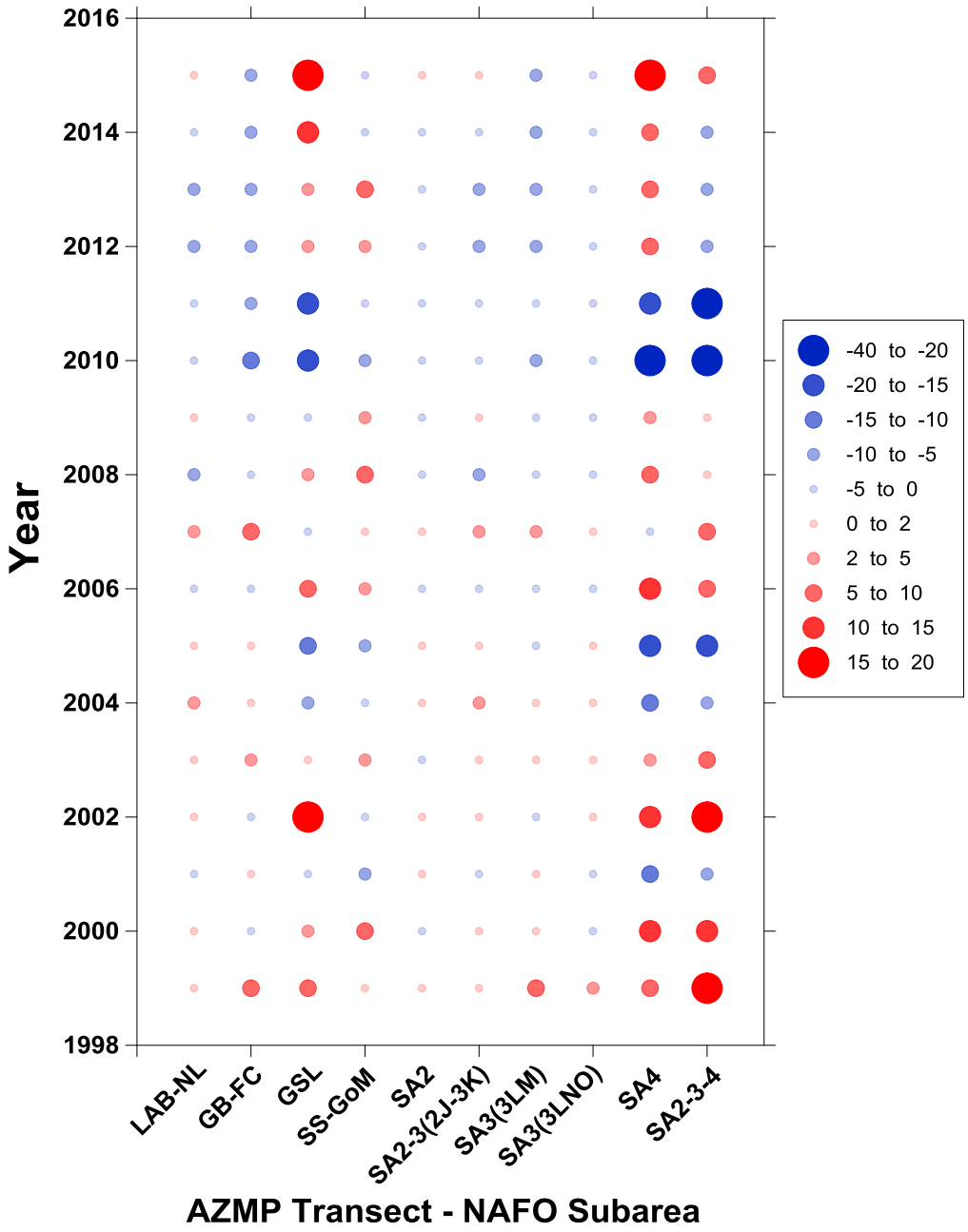

Fig. 17. Composite sums of annual standardized anomalies of nutrient and phytoplankton indices from different combined AZMP transects and NAFO Subareas; Labrador and Newfoundland Shelf (LAB-NL), Gulf of St. Lawrence (GSL), Scotian Shelf and Gulf of Maine (SS-GoM), Subarea 2 (SA2), Subarea 2 and 3 (SA2-3 (2J-3K Div.), Subarea 3 SA3 (3LM Div.), Subarea 3 (SA 3 (3LNO Div.), Subarea 4 (SA4), Subarea 2-3-4 (SA 2-3-4) during 1999-2015. Blue symbols represent values below the long term average for each region; red symbols represent values above the long term average. The size of the symbols reflects the magnitude of the departure of that year's average (in terms of the standard deviation of the time series of annual averages) from the long term average for the region.

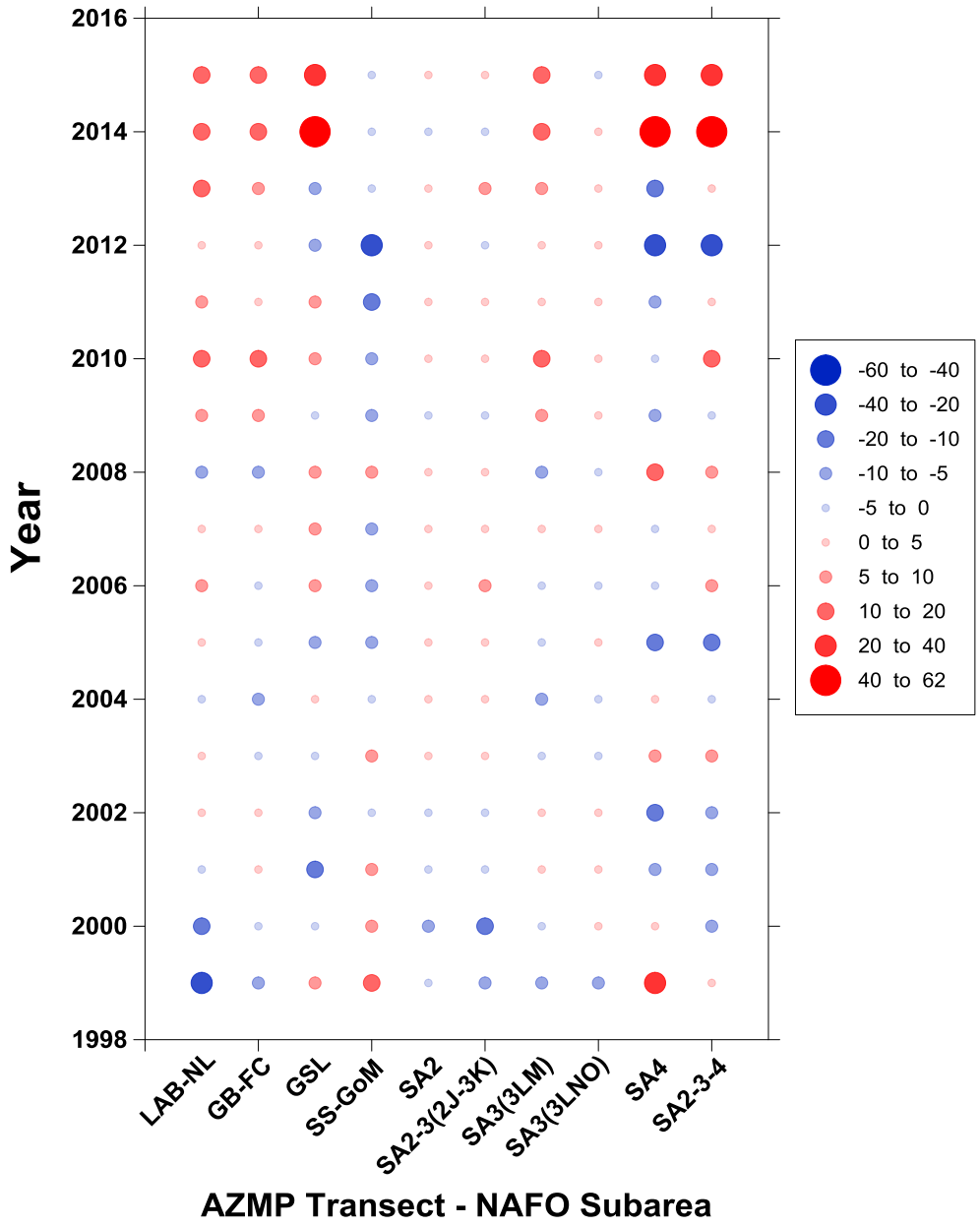

Fig. 18. Composite sums of annual standardized anomalies of zooplankton functional group indices from different combined AZMP transects and NAFO Subareas; Labrador and Newfoundland Shelf (LAB-NL), Gulf of St. Lawrence (GSL), Scotian Shelf and Gulf of Maine (SS-GoM), Subarea 2 (SA2), Subarea 2 and 3 (SA2-3 (2J-3K Div.), Subarea 3 SA3 (3LM Div.), Subarea 3 (SA 3 (3LNO Div.), Subarea 4 (SA4), Subarea 2-3-4 (SA 2-3-4) during 1999-2015. Blue symbols represent values below the long term average for each region; red symbols represent values above the long term average. The size of the symbols reflects the magnitude of the departure of that year's average (in terms of the standard deviation of the time series of annual averages) from the long term average for the region.

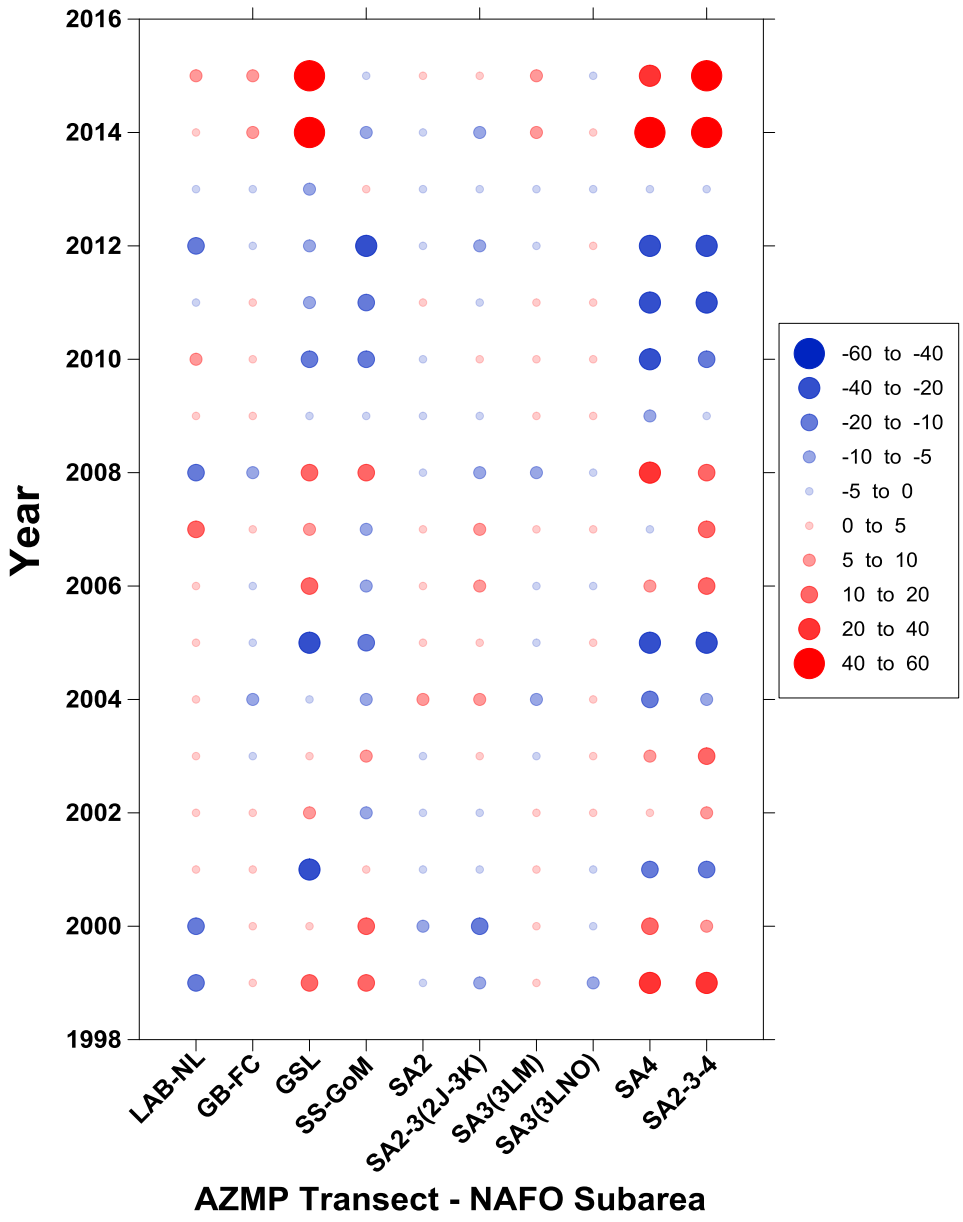

Fig. 19. Sum of annual standardized anomalies of composite trophic index of nutrient, phytoplankton and zooplankton functional groups from different combined AZMP transects and NAFO Subareas; Labrador and Newfoundland Shelf (LAB-NL), Gulf of St. Lawrence (GSL), Scotian Shelf and Gulf of Maine (SS-GoM), Subarea 2 (SA2), Subarea 2 and 3 - SA2-3 (2J-3K Div.), Subarea 3 - SA3 (3LM Div.), Subarea 3 - SA 3 (3LNO Div.), Subarea 4 (SA4), Subarea 2-3-4 (SA 2-3-4) during 1999-2015. Blue symbols represent values below the long term average for each region; red symbols represent values above the long term average. The size of the symbols reflects the magnitude of the departure of that year's average (in terms of the standard deviation of the time series of annual averages) from the long term average for the region.

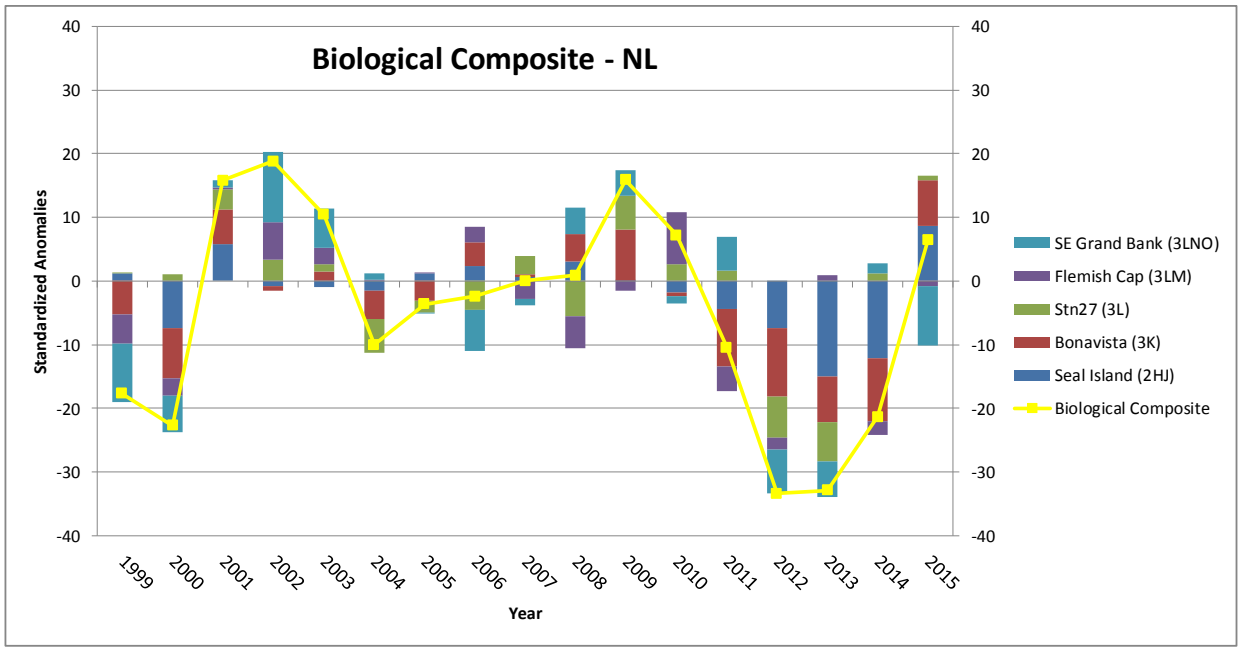

Fig. 20. Composite biological index (yellow line) derived by summing the standardized anomalies of nutrient, phytoplankton biomass and ocean colour, and zooplankton time series from the Newfoundland and Labrador individual transect components and sub-regions.

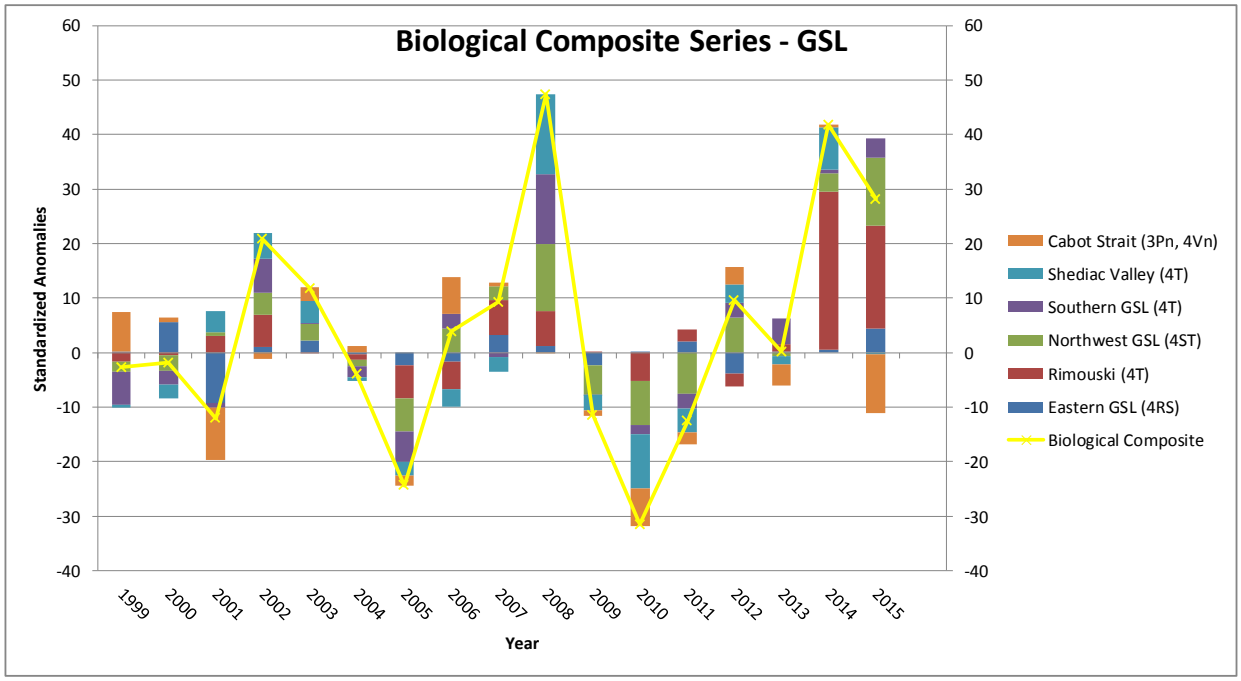

Fig. 21. Composite biological index (yellow line) derived by summing the standardized anomalies of nutrient, phytoplankton biomass and ocean colour, and zooplankton time series from the Gulf of St. Lawrence individual transect components and sub-regions.

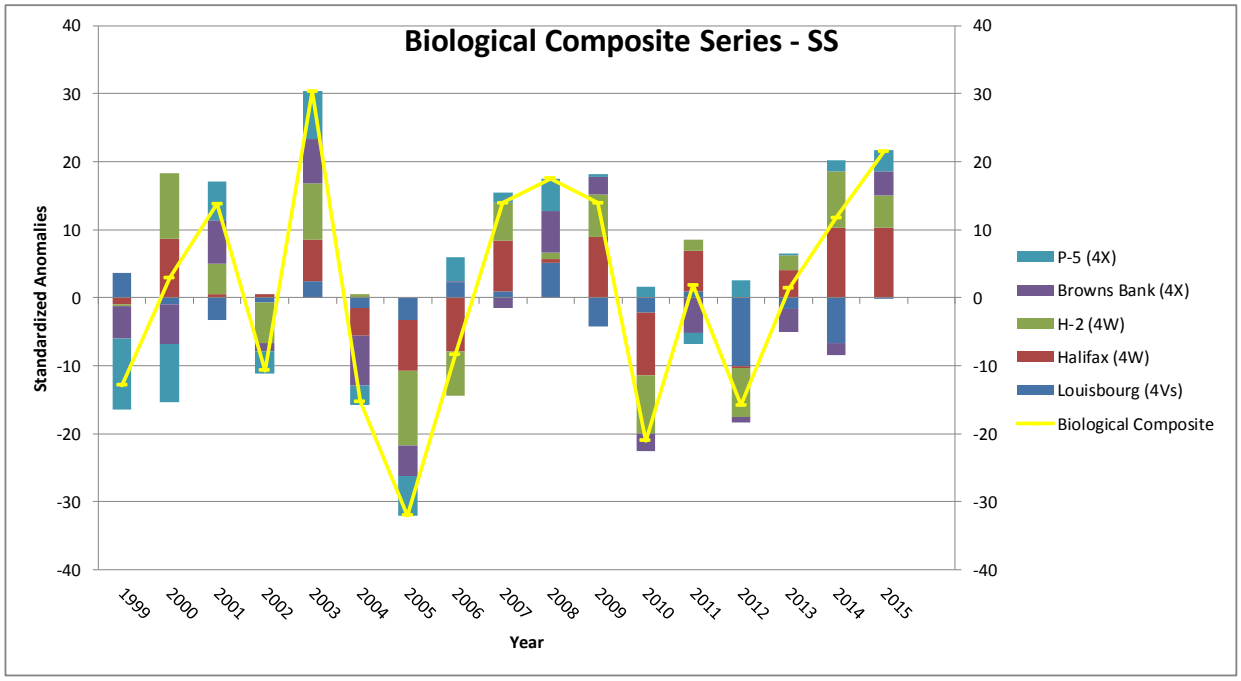

Fig. 22. Composite biological index (yellow line) derived by summing the standardized anomalies of nutrient, phytoplankton biomass and ocean colour, and zooplankton time series from the Scotian Shelf individual transect components and sub-regions.